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GEOTHERMAL EVALUATION AND WELL DEVELOPMENT OF THE CAMP AQUA SITE

Prepared for

MONTANA DEPARTMENT of NATURAL RESOURCES and CONSERVATION

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GEOTHERMAL EVALUATION AND WELL DEVELOPMENT OF THE CAMP AQUA SITE

Prepared by

Thor Jackola
Jackola Engineering
P.O. Box 1134
Kalispell, MT 59901

August, 1982

Prepared for

Montana Department of Natural Resources and Conservation
32 South Ewing, Helena, Montana 59620
Renewable Energy and Conservation Program
Grant Agreement Number 551-811

Available from

Montana State Library, 1515 East Sixth Avenue
Justice and State Library Building, Helena, Montana 59620

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Jackola Engineering Co.

September 1, 1982

State of Montana
DNRC
Attention: Ms. Peggy Nelson
32 South Ewing
Helena, MT 59620

Re: Final Report - Production Well Grant #551-811

Dear Ms. Nelson:

This report is the followup of the status report issued February 12, 1982, and is issued as a final production well report. At this point, financing has not been established for the "Agricultural By-Product Plant". It is the desire of the grantee to request extension to June 30, 1983, the provision of drilling the two injection wells, if it were to the pleasure of the Department of Natural Resources and evidence of adequate and complete financing be established. This request is referenced as to Grant Amendment dated March 25, 1982.

The production well development was performed under Permit #32593. The drilling was performed by Liberty Drilling of Kalispell, Montana. Results and logs are contained in this report. William E. Work, Inc. performed hydrology consulting services.

We are appreciative and wish to recognize all the efforts of Mr. Sonderegger and Mr. Donovan of Montana Tech for their interest and help in the data development and assessment of the well.

The financing of the "Agricultural By-Product Plant" has been and continues to be actively pursued in the money markets. This effort has had its share of frustration and difficulties, however, the intent is to continue to pursue for the forseeable future. It is our opinion, as evidenced through our efforts to establish the plant concept, that this type of industrial development is crucial and necessary for Montana to develop and to enhance the industrial and agricultural economic structure and provide a hedge against the inflationary effects of energy costs within the state. Extensive preliminary engineering and marketing studies have revealed the following facts:

575 SUNSET BOULEVARD · P.O. BOX 1134 · KALISPELL, MONTANA 59901 · 406-755-3208

1. Alcohol fortified gasoline receives a federal 4¢ per gallon excise tax exemption. Many states, including Montana, have added additional tax benefits to encourage alcohol use.

2. A ten percent energy investment tax credit applies to proposed plants and facilities.

3. Decreasing petroleum resources are steadily increasing alcohol demand and price.

4. Increasing demand for high octane will accelerate the price differential between unleaded gasoline and premium fuels.

5. There is a well documented need to decrease dependence on foreign oil imports.

6. Ethanol production in the U.S. will increase by 500% in the next ten years.

7. Foreign oil imports will increase by 9% in the next ten years.

8. The geothermal water source available at Site No. 1 will produce 30% of the heat energy required in the process.

9. Vital glutens as a primary by-product will be a profitable operation at current prices while competitive with foreign imports.

10. An in-plant produced fungal amylase used in conversion will maintain plant efficiencies and turn-a-around time at highest possible levels.

11. Fungal Amylase as a salable by-product will be highly profitable at current prices.

12. Distillers dried grains with preserved vitamins are a superior beef and dairy cattle feed, and are regionally competitive with fundamental cattle feeds.

13. Purified Liquid Carbon Dioxide will be a profitable by-product salable to identified gas manufacturers and others.

14. The sale of small quantities of specialty organic by-products such as Amyl Alcohol will make their extraction profitable and simultaneously assure ethanol product quality.

15. A multi by-products grain processing facility has a distinct operating advantage over its traditional market rivals in reduced per pound product operating cost and final sales efficiency.

16. Product percentage splits can be adjusted to accomodate minor market shifts.

The Hot Springs site approaches the geographic center of western Montana and is in the current traveled route of grain raw materials. The plant would consume about 5% of the current production of wheat and 3.5% of current barley production from the 16 surrounding counties. Unplanted land exists that would provide well in excess of this plant's needs if placed into crops. 1978 cattle statistics indicated in excess of 450,000 head exist within the area. It is anticipated that 71 people will be required to operate the plant and that payroll including taxes and benefits will approach $2,000,000 annually. The annual sales volume is expected to exceed $45,000,000 with the first three years of operation.

The long term growth plan is to develop six additional sites over a ten to twelve year period. It is estimated that a total capitalization in excess of $180,000,000 will be required to support this growth and loan requirements in the area of $70,000,000 to accomplish the seven plants in the period would be necessary.

State government has been very helpful in the development of this viable industrial concept and we wish to recognize the efforts of the Governor's office, The Department of Natural Resources, The Department of Health and Environmental Sciences, together with the EPA, The Department of Agriculture and the many other involvers who have assisted the effort to date. Our goal is that these efforts will yet result in a fruitful result to the State of Montana as well as the corporate entity of Materials Development Inc., which has put, and continues to put, such tireless effort and resolve to this plant development.

Last, but not least, our personal thanks to the Management and Staff of the Renewable Energy Bureau for the sincere and dedicated support and assistance in bringing about this grant and their guidance and thoughtfulness through the efforts accomplished to date. We look forward to your response to our extension request and respectfully submit this report as justification of release of funds expended to date.

Respectfully yours,

Thor A. Jackola

TAJ:sh

cc: Mr. Van Jamison
Mr. Jeff Birkby
Mr. Marshall Murray
Mr. Heidegger
Mr. Christensen
Mr. Howser
Mr. Wm. E. Nork

SECTION 2

SUMMARY & CONCLUSIONS

551-811

SECTION 2

SUMMARY & CONCLUSIONS

551-811

Geothermal resource evaluations were conducted under the State of Montana DNRC Grant #551-811, at a site in Lake County, Montana. The site is known as Camp Aqua and is located in Section 29, Twonship 22 North, Range 23 West. The site is a proposed location for an "Agricultural By-Product Plant" which plans to use the geothermal energy as a practical energy source.

As background, the above site was the location of a 240' well drilled in 1913, which unexpectedly produced 125.6° F. water and flowing. A test was conducted on this well on October 22, 1980, which indicated the well to be flowing at 127 gpm at an estimated 14.5 psig at the well head. The pH was recorded at 8.36 and temperature was recorded at 125.6° F. No flow change was observed in 8 hours testing. Local information suggests that significant restriction exists in the well as plugging attempts were made at time of drilling.

The Bureau of Mines drilled a well approximately 250 feet northwest of the old Camp Aqua well on the Gossett property, under the direction of Mr. Donovan of Montana Tech in Butte. This well was drilled to a depth of 1,022 feet and produced 120.2° F. water and flowing. This well was completed in January of 1981. The gravel aquifer was encountered at the 240 foot level and extended to a rock level at 264 feet. Rock was experienced to the 1,002 foot level with water bearing fractures occurring at various levels. For more details about this well, contact should be made with Mr. Donovan or Mr. Sonderegger at Montana Tech in Butte, as the above information was made available through their courtesy.

A primary function of this grant was to drill a production well at a suspected location of the hottest water within the property boundaries. In reviewing the "Donovan Report" and field efforts of William E. Work, Inc. personnel, the temperature contours lacked data points immediately southeast of Camp Aqua which would serve to refine the isotherms.

Due to the blank area of data points, a temperature gradient hole (CAT-1) was planned and located with a second location to follow, if necessary. The location was approximately 1,150 feet southeast of Camp Aqua well. The temperature gradient hole was drilled during the week of January 25, 1982, and the results indicated a 111.2° F. temperature. A 1½" CPVC Schedule 80 pipe was installed to 254 foot level. Aquifer level was encountered at the 242 foot level. A measurement of temperature on May 27, 1982, indicated a downhole temperature of 119.1° F.

Summary and Conclusions Cont'd

With the input of the temperature gradient hole information, the suggested spot for the production well was located approximately 250 feet southeast of the Camp Aqua well. A 12" steel casing was grouted to 99'-4" and a 12" hole was drilled to 260' level cased with 10 3/4" O.D. X .375 wall steel casing. A Mills knife was used to perforate casing from 259' level up to 250'. The slots are 3/8" X 4". At flowing condition of 250 gpm and above grade, a temperature measurement of 128.6° F. was taken. The casing was at rock contact.

When the casing was sealed in the bedrock and flow was stopped, at temperature measurement of 135° F. was logged at the 235 foot level. A deeper measurement was not possible because of 10" Ø stabilizer presence in the casing. A Johnson-Keck DTM-75 temperature logging device accurate to ± 0.1° F. was used. The well flow is measured at 1,160 gpm with estimated capability of 1,600 gpm. The close-in pressure was approximately 10 psig.

The chemical analysis of the production well indicates low calcium but elevated concentrations of Sodium and Chloride. Flouride is high and pH of 8.5 with little Carbonate suggests a shift in the Bicarbonate-Carbon Dioxide equilibria toward Carbon Dioxide. 4.8 Mg/L of Methane was detected in the water. The noted detection of Methane suggests the water source being sealed with the presence of the overlying strata of hard pan.

Higher water temperatures that are not normal at shallow depths are commonly the result of convective flow of hot water that takes on heat deep in the subsurface and transfers it to rock near the surface. The temperature depth profile is suspect to vary according to the salinity of the subsurface fluids and the depth of the local water table. Data gathered to date is not adequate to fully assess the thermal energy extractable, however, the data of immediate wells and this well suggests the resource to be more than adequate for the plant development with the resource base larger but unknown. A report by Mr. Sonderegger and Mr. Wideman of Montana Tech suggests that transmissivity of the aquifer to be 125,000 gallons per day per foot based on 1,100 gpm flow of this well.

It is expected that this resource is of meteoric origin and is geopressured in the sense that the pressure exceeds that of the water column. This hydrothermal convection system is suspect of deriving heat from large volumes of rock by deep circulation of water along permeable zones of possibly layered beds and/or a network of faults and fractures. It is anticipated that the attained temperature is a factor primarily dependent upon the regional heat flow magnitude and the depth to which the water circulates. Recharge of the system may occur over mountain areas and adjacent valleys.

The results of this grant indicate relatively accurately that the hottest water at this Camp Aqua site has been located and is suspect that continued long range use will tend to raise well temperatures as the upper level surrounds adjust to the water flow. What this also suggests that utilization

of this well will have negligible, if any, effect on surrounding wells because of the hydrothermal convection system recharge. It may be added that uncontrolled release of water from the large water aquifer in the area could be dramatically improved if they were able to be brought under control in the event they exist.

Assuming heat valued at $4/million Btu's and at the 1,160 gpm flow rate of the well, an added production of heat of 3° F. will be worth approximately $160 per day. This would assume utilizing continuous flow the year round.

The plant as currently proposed would utilize geothermal water as follows:

1. Contact Water

    a. Feed materials drying

    b. Washing and Screening

    c. Flour preparation

    d. Enzyme preparation

    e. Yeast culture

    f. Grain slurry preparation and mash cooking

    g. Starch conversion to sugar

    h. Fermentation

    i. Beer holding

    j. Beer distillation

    k. Extractive distillation

    l. Amyl alcohol production

    m. Ethanol dehydration (Azeotropic Distillation)

    n. Ethanol denaturization

    o. Stillage separation

    p. Pre-drying

    q. Evaporation

    r. Supplement conditioning

    s. Gluten preparation

2. Non-contact Geothermal Water as Heat Transfer Media

   a. Heaters for cooking

   b. Heaters for conversion

   c. Heaters for distillation

   d. Heaters for evaporation

   e. Air heaters

   f. Waste liquid chemicals heating

   g. Heaters for emission control

   h. Heaters for tracing tanks and pipelines (winter service)

   i. Heaters for liquid waste treatment systems

   j. Tank farm heaters

   k. Building heaters

Variables requiring additional review and related to the effective utilization of the geothermal resource include the following:

1. Review the practicality and value to remove and utilize available Methane.

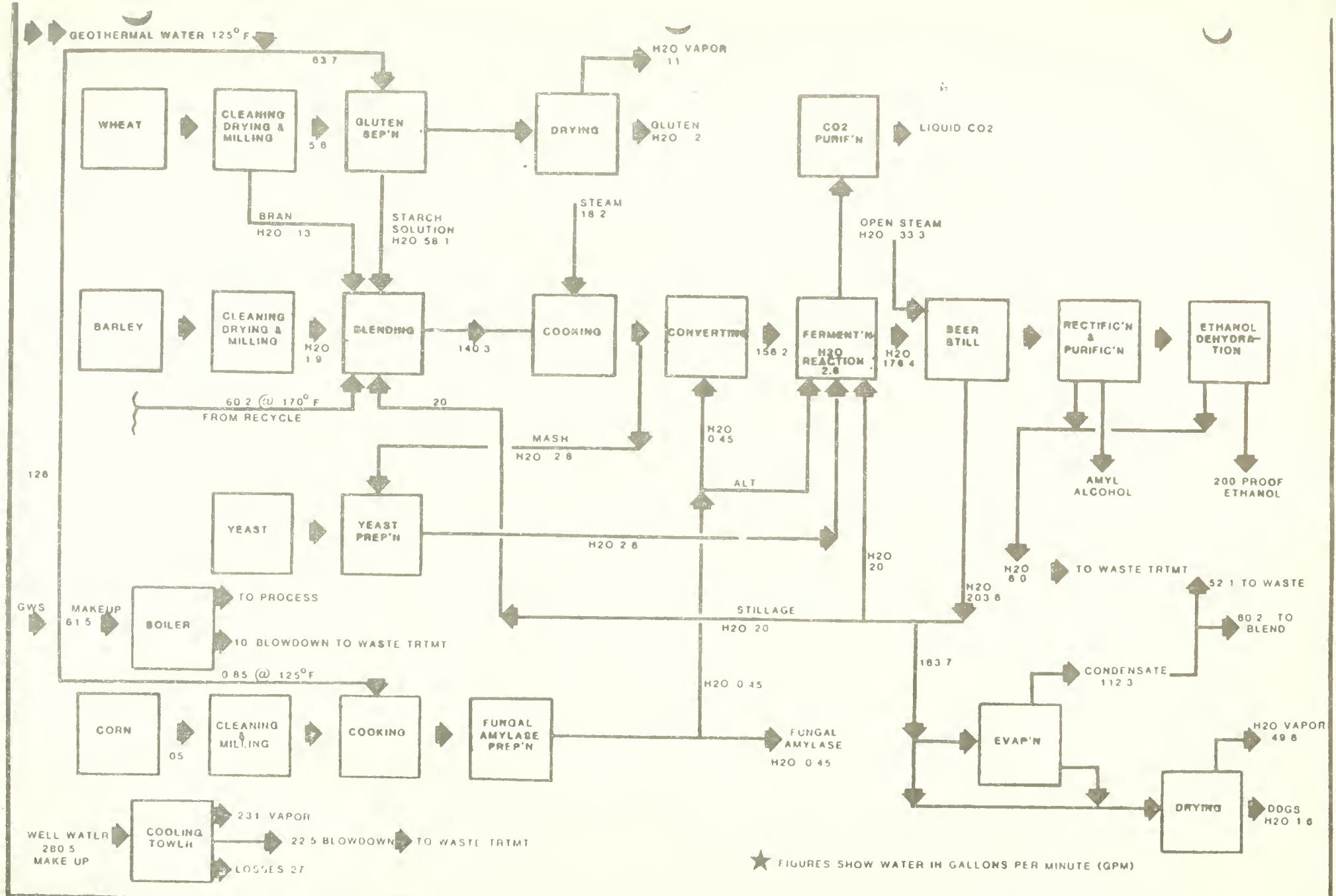
2. Evaluate heat pump systems to raise energy level of the available resource.

3. Evaluate compatible developments at the site to utilize the resource such as nursery or hydroponics.

Attached is a Block Flow Diagram of the plant water balance. It should be noted that these balances were made with an anticipated average raw material moisture level and leaving product moisture level. Variations will result based on actual plant throughput.

References:

* "Donovan Report" - Montana Tech
* Sonderegger & Wideman Reporting - Montana Tech
* Wm. E. Nork, Inc. Reporting
* Northern Testing Lab Reporting
* Anderson & Lund - Direct Utilization of Geothermal Energy



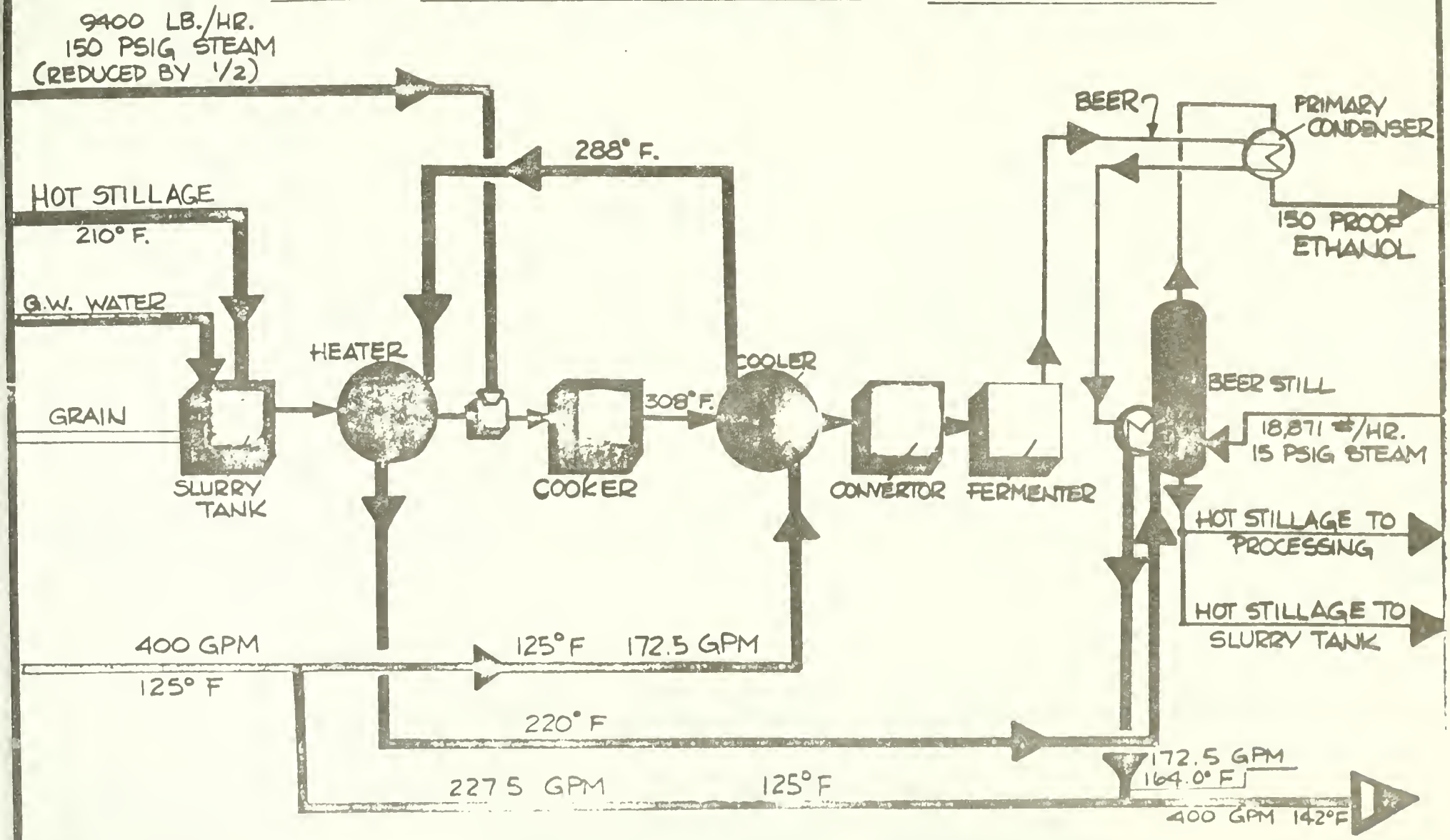
BLOCK FLOW DIAGRAM
WATER BALANCE

ETHANOL PRODUCTION
FOR GASOHOL USING
GEOTHERM ENERGY

JACKOLA
ENGINEERING
COMPANY

DATE
JANUARY 15, 198

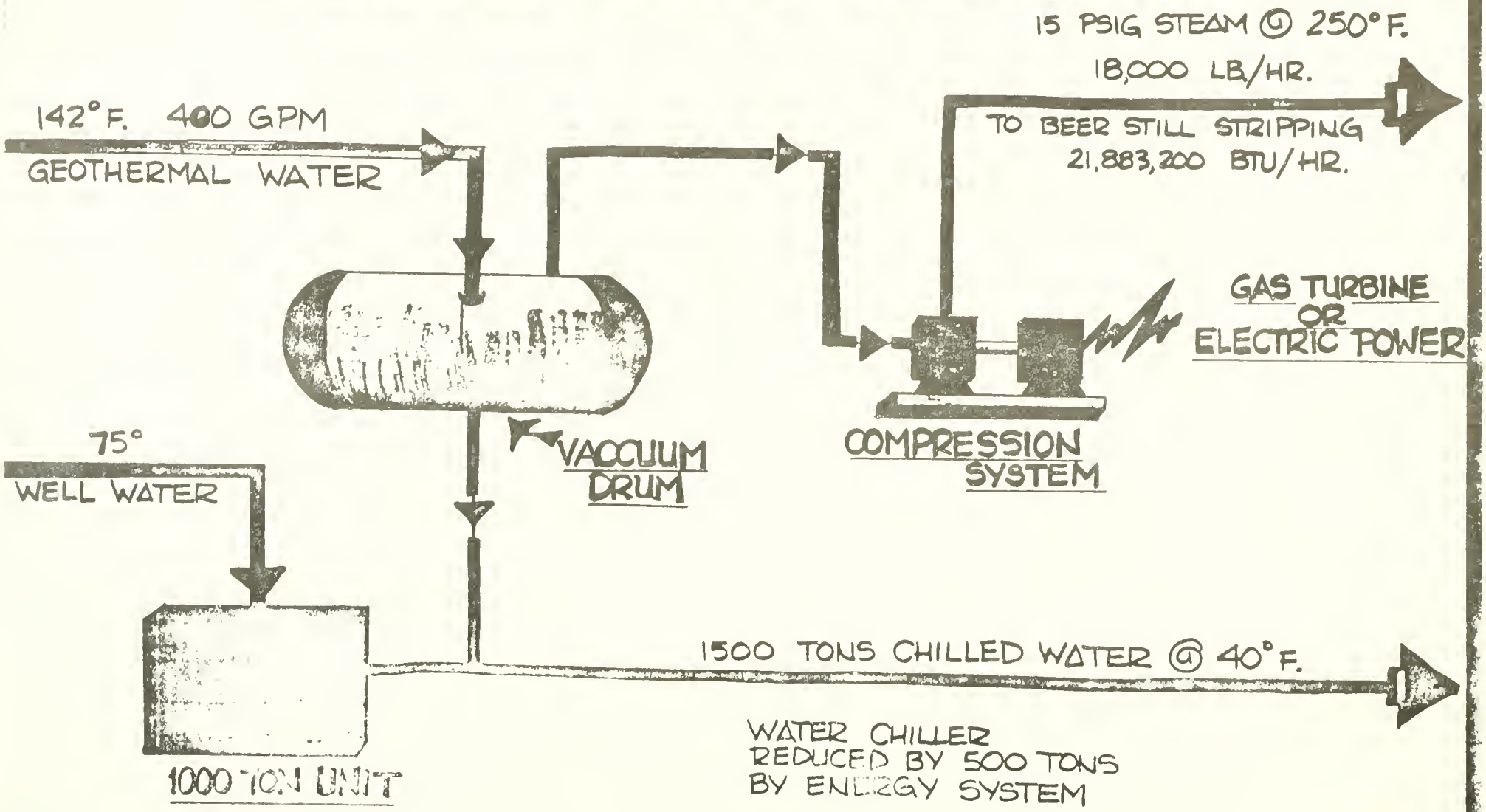
PRIMARY ENERGY CASCADE FOR GEOTHERMAL WATER



Jackola Engineering Co.
P.O. Box 1134
Kalispell, Mt. 59901

P.N.- J- 3
Jackola Engineering Co.
P.O. Box 1154
Kalispell, Mt 59901
406/755-3208

GEOTHERMAL WATER STEAM GENERATION AND CHILLED WATER PRODUCTION



SECTION 3

TEMPERATURE GRADIENT HOLE DATA

551-811

RETURN TO:

Water Rights Bureau Field Office
Department of Natural Resources and Conservation
P. O. Box 860
3220 Highway 93 South
Kalispell, MT 59901

I (WE), JACKOLA ENGINEERING CO. hereby terminate

my (our) Notice of Completion of Ground-water Development No. RECEIVED 2-16-82

My (our) reason for this action is: DNRC POLICY DICTATES THAT A 602 IS NOT NECESSARY FOR THE USE DESCRIBED.

X [signature] 3/24/82
Signature Date

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
WATER RIGHTS BUREAU

TED SCHWINDEN, GOVERNOR

P.O. BOX 860

STATE OF MONTANA

(406) 755-9288

KALISPELL, MONTANA 59901

March 8, 1982

RECEIVED MAR 0 1982

CERTIFIED #713 461

Jackola Engineering Co.
Attn: Thor A. Jackola
P.O. Box 1134
Kalispell, MT 59901

RE: Notice of Completion - temporary gradient hole, Lake County Montana, Section 29, Township 22 North, Range 23 West, Camp Aqua, near Hot Springs, Montana.

Dear Sir:

I have reviewed the above referenced Notice of Completion. The beneficial use described on your Notice falls in a category described by the Department of Natural Resources & Conservation as "dewatering" (a process whereby water must be removed so another activity can go on - water sampling). Montana's waters are subject to appropriation only for beneficial uses; however, case law indicates that the determination of beneficial use depends on the circumstances in each case. It is the Department's opinion that "a well drilled and used soley for groundwater level observation and record keeping or minor occassional sampling for water quality purposes" may not require a Notice of Completion.

Based upon the information before me, it is my opinion (based upon the above referenced policy) that a Notice of Completion need not be submitted for the described use. If the well is ever put to use other than as presently described, a Notice of Completion may be submitted at that time. In the event that I do not have all of the facts, please resubmit the Notice with the following additional information:

1. $5.00 filing fee
2. Clarifying of water right owner (applicant name)
3. Total rate of water used
4. Total annual volume of water used for the use indicated
5. The period of use of water from the well.

You have thirty (30) days to resubmit the Notice of Completion, if deemed necessary. The Notice will be terminated at that time if no response is received. Please call or write if I can be of further assistance.

The concern (that the well may start flowing again) you voiced over the phone to Chris Brewer, our Analyst, is properly addressed in Title 85-2-505 (1) (copy enclosed).

Sincerely,

Charles F. Brasen

Charles F. Brasen
Area Office Supervisor
Water Rights Bureau

CFB/lc

Enclosures

Jackola Engineering Co.

February 12, 1982

State of Montana
Water Rights Bureau
Dept. of Natural Resources
and Conservation
P. O. Box 860
Kalispell, MT 59901

Attention: Mr. Jim Reybein

Re: Temperature Gradient Hole
Lake County, MT. Sec. 29, T22N, R23W
Camp Aqua, Near Hot Springs, MT

Dear Sir:

Attached is Form 602 RT/81, Notice of Completion for the above referenced Temperature Gradient Hole. We have attached additional data and diagrams concerned with the effort.

Kindly review the completion notice and let me know if any further information is necessary.

Very truly yours,

Thor A. Jackola

TAJ:sh

cc: Jeff Birkby, Helena
Dale Buganic, Wm. E. Nork, Inc.

575 SUNSET BOULEVARD - P.O. BOX 1134 - KALISPELL, MONTANA 59901 - 406-755-3208

Form No. 602 R7/81

NOTICE OF COMPLETION OF GROUND-WATER DEVELOPMENT

For ground-water developments with a maximum use of less than 100 gpm

(Use Form 600, Application for Beneficial Water Use Permit for undeveloped springs or appropriations of 100 gpm or more.)

IMPORTANT

The right to the use of ground water is not automatic. Your priority will be determined by the date of filing this form. STATE LAW REQUIRES THAT THIS FORM BE FILED BY THE WELL OWNER WITHIN 60 DAYS AFTER THE WATER HAS BEEN PUT TO BENEFICIAL USE. Attach the **proper filing fee**, payable to the Department of Natural Resources and Conservation and submit to your area water rights field office as listed on the back side.

FOR DEPARTMENT USE ONLY

Notice No
Date Received
Time A.M./P.M.
Transmittal No
Fee Received $
Received By
Refund Made

(Please type or print in ink)

1. NAME(S) Jackola Engineering Co.
MAILING ADDRESS P. O. Box 1134
CITY Kalispell STATE MT ZIP 59901
HOME PHONE 755-6286 OTHER PHONE 755-3208

2. SOURCE OF GROUND WATER SUPPLY [ ] WELL [ ] DEVELOPED SPRING (excavation performed)
[ ] PIT [X] OTHER (describe) Temperature Gradient Hole

3. DATE WATER PUT TO BENEFICIAL USE:
NAME AND ADDRESS OF WELL DRILLER OR CONTRACTOR: (If applicant or other please indicate.)
Name Liberty Drilling Co.: Northern Testing Labs
Address Kalispell, MT Great Falls, MT
Maximum withdrawal 175 gallons per minute (as tested by driller)

Does this well replace an existing well? Yes X No See Attached Report
If Yes, complete the following information pertaining to the existing (old) well
Depth ft G P M Date drilled

If Yes, contact your area field office as you may be able to file a change in point of diversion and retain the priority date of the old well.

4. POINT OF DIVERSION (Your legal land description may be obtained from your deed, county assessor, or clerk and recorder. Complete the following and attach an aerial photo or survey map showing the location of your well or development and your place of use, if available.)

Lot____ Block____ Subdivision
Government Lot____ or SE ¼ SW ¼ NE ¼ Section 29
TWP. 22N N/S RGE. 23W E/W County Lake County

5. PLACE OF USE: (If more than one place of use, attach additional sheets. If same as the point of diversion, CHECK X.)

Lot____ Block____ Subdivision
Government Lot____ or ¼ ¼ ¼ Section
TWP.____ N/S RGE.____ E/W County

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION DNRC
32 SOUTH EWING HELENA MONTANA 59620 449-3962

6. AMOUNT OF WATER, USE TO WHICH IT HAS BEEN APPLIED, AND PERIOD OF USE:

Total Rate Used: None gallons per minute

☐ DOMESTIC: (house, lawn, garden) No. of families supplied _____.
No. of acres of lawn/garden irrigated _____.

from _____ (month/day) to _____ (month/day) inclusive, of each year

☐ STOCK: Approximate maximum number and type of livestock._____.

from _____ (month/day) to _____ (month/day) inclusive, of each year

☐ IRRIGATION: Total No. of acres irrigated _____.
Type of crop _____.

Amount of water used _____ acre-feet/year.
from _____ (month/day) to _____ (month/day) inclusive, of each year

☒ OTHER: Describe Temperature Gradient Hole; well flowed 175 gpm while temporary casing in place; stopped flowing when removed.
Amount of water used _____ acre-feet/year or _____ Gal./day
from _____ (month/day) to _____ (month/day) inclusive, of each year

7. REMARKS: (Use this space for additional information, if needed, to describe development.)

See attached report: One additional comment is that when temporary casing was removed, the well stopped flowing and siezed itself.

8. THE APPROPRIATOR CERTIFIES THAT THE STATEMENTS APPEARING HEREIN ARE TO THE BEST OF HIS/HER KNOWLEDGE TRUE AND CORRECT.

[illegible] (signature) 2/8/82 (date)

SUBMIT THE COMPLETED FORM AND PROPER **FILING FEE** TO THE APPROPRIATE WATER RIGHTS BUREAU FIELD OFFICE, SERVING THE COUNTY IN WHICH THE DEVELOPMENT LIES, AS LISTED BELOW

Montana Water Rights Bureau Area Field Offices

HELENA
32 South Ewing
Helena, Montana 59620
Phone 449-3634
Serving Deer Lodge, Powell, Lewis and Clark, Broadwater, Silver Bow, Jefferson and Beaverhead Counties

MISSOULA
2101 Bow Street
P.O. Box 5004
Missoula, Montana 59806
Phone 721-4284
Serving Missoula, Granite, Ravalli, and Mineral Counties

GLASGOW
110 5th Street South, Room 106
P.O. Box 894
Glasgow, Montana 59230
Phone 228-2561
Serving Daniels, Dawson, Garfield, McCone, Phillips, Richland, Roosevelt, Sheridan and Valley Counties

BOZEMAN
Bozeman Professional Building
30 East Olive, Suite 1-D
Bozeman, Montana 59715
Phone 586-3136
Serving Gallatin, Park and Madison Counties

HAVRE
Old Highway 2
P.O. Box 1828
Havre, Montana 59501
Phone 265-5516
Serving Blaine, Chouteau, Glacier, Hill, Liberty, Pondera, Teton and Toole Counties

BILLINGS
1537 Avenue D, Suite 121
Billings, Montana 59101
Phone 248-6540
Serving Big Horn, Carbon, Stillwater, Treasure, Yellowstone and Sweet Grass Counties

KALISPELL
3220 Highway 93 South
P.O. Box 860
Kalispell, Montana 59901
Phone 755-9288
Serving Flathead, Lake, Lincoln and Sanders Counties

LEWISTOWN
613 NE Main Street
P.O. Box 438
Lewistown, Montana 59457
Phone 538-7459
Serving Cascade, Fergus, Golden Valley, Judith Basin, Meagher, Musselshell, Petroleum and Wheatland Counties

MILES CITY
5 North Prairie
P.O. Box 276
Miles City, Montana 59301
Phone 232-6359
Serving Carter, Custer, Fallon, Powder River, Prairie, Rosebud and Wibaux Counties.

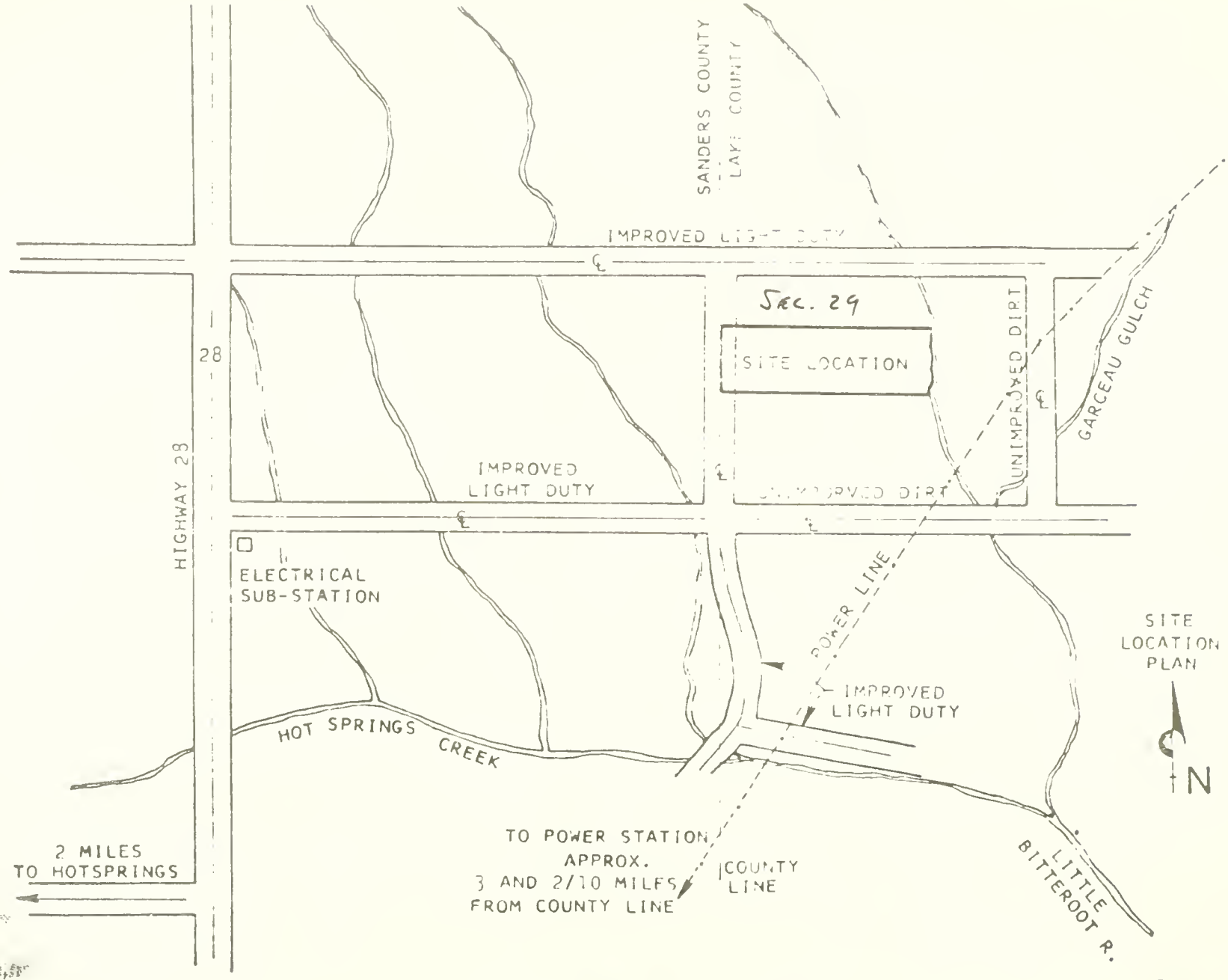


Figure 2-1. Site location

Dreb 1982

WILLIAM E. NORK, Inc.

CONSULTING SERVICES IN HYDROLOGY AND GEOLOGY

1026 W. First Street • Reno, Nevada 89503

Phone (702) 322-2604

February 4, 1982
82-231

Thor Jackola
JACKOLA ENGINEERING CO.
P.O. Box 1134
Kalispell, MT 59901

RE: Camp Aqua

Dear Mr. Jackola:

During the week of January 25, 1982, a temperature gradient hole was constructed at the Camp Aqua project, Hot Springs, Montana. The purpose of the hole was to provide temperature and water chemistry data for a blind spot area immediately southeast of the Camp Aqua well. The temperature gradient hole, designated Camp Aqua Temperature No. 1 (CAT-1), is located approximately 1,150 feet S32°E of the present water supply well at Camp Aqua.

Hole construction

CAT-1 was constructed jointly by Northern Testing Labs and Liberty Drilling Co. of Great Falls and Kalispell, respectively. The construction summary is chronicled below.

01/26/82 A 10-inch nominal diameter borehole was augered to a depth of 50 feet. A total of 58.33 feet of 6-5/8 inch O.D. 0.250-inch sidewall steel well casing was installed to a depth of about 57 feet and the annulus sealed from 50 feet to land surface.

01/27/82 Drilled nominal 4-inch hole by mud rotary method from 50 feet to a depth of 243 feet.

01/28/82 Installed 3½ inch drive casing to 243 feet. Drilled nominal 3-inch hole from 243 feet to a depth of 257 feet and drove casing to a depth of about 253 feet.

01/29/82 Installed 1.5-inch I.D. Schedule 80 CPVC pipe from T.D. to 1.75 feet above land surface. Collected water sample for chemical analysis, pulled drive casing, installed packer assembly and secured well head.

Refer to CAT-1 construction diagram and well head/packer assembly detail.

Data collection and interpretation

CAT-1 penetrated sand from land surface to a depth of about 20 feet, clay and silty clay from 20 to 238 feet, indurated clay from 238 to 242 feet, and sand, gravel and cobbles from 242 to T.D. (A copy of the log of the borehole is enclosed). Flowing artesian conditions did not prevail until after drilling fluid was diluted and the hole flushed with clean water. Artesian flow was measured at about 175 gpm and at a temperature of 111.2°F (44°C). The shut-in artesian pressure head was not measured although the artesian head was noted to be at least 20 feet above land surface.

The temperature of the ground water measured in CAT-1 was used to refine a temperature contour map of the project area and near vicinity (Refer to figure). Although the temperature of the ground water at this site was not as hot as anticipated, it did serve to better delineate the temperature of ground water beneath Camp Aqua. Examination of the isotherms suggests that the hottest ground water in the alluvium beneath the project area may be found just south and east of the existing Camp Aqua water-supply well.

Previous investigations indicated bottom-hole temperatures in regional flowing artesian wells to be one to two degrees Fahrenheit

higher than temperatures measured at the well head. Given the 125.8°F measured in the Camp Aqua well, temperature of the ground water may reach 126.8° to 127.8°F. If the temperature does increase a short distance southeast of the existing well, as the temperature data suggest, then temperatures of approximately 130°F may be encountered in a new well.

Results of the chemical analysis of the water sample collected from CAT-1 are not yet available.

Please contact our office if you have any questions.

Sincerely,

WILLIAM E. NORK, INC.

Dale C. Bugenig

Dale C. Bugenig
Hydrogeologist

DCB:bh

Enclosures

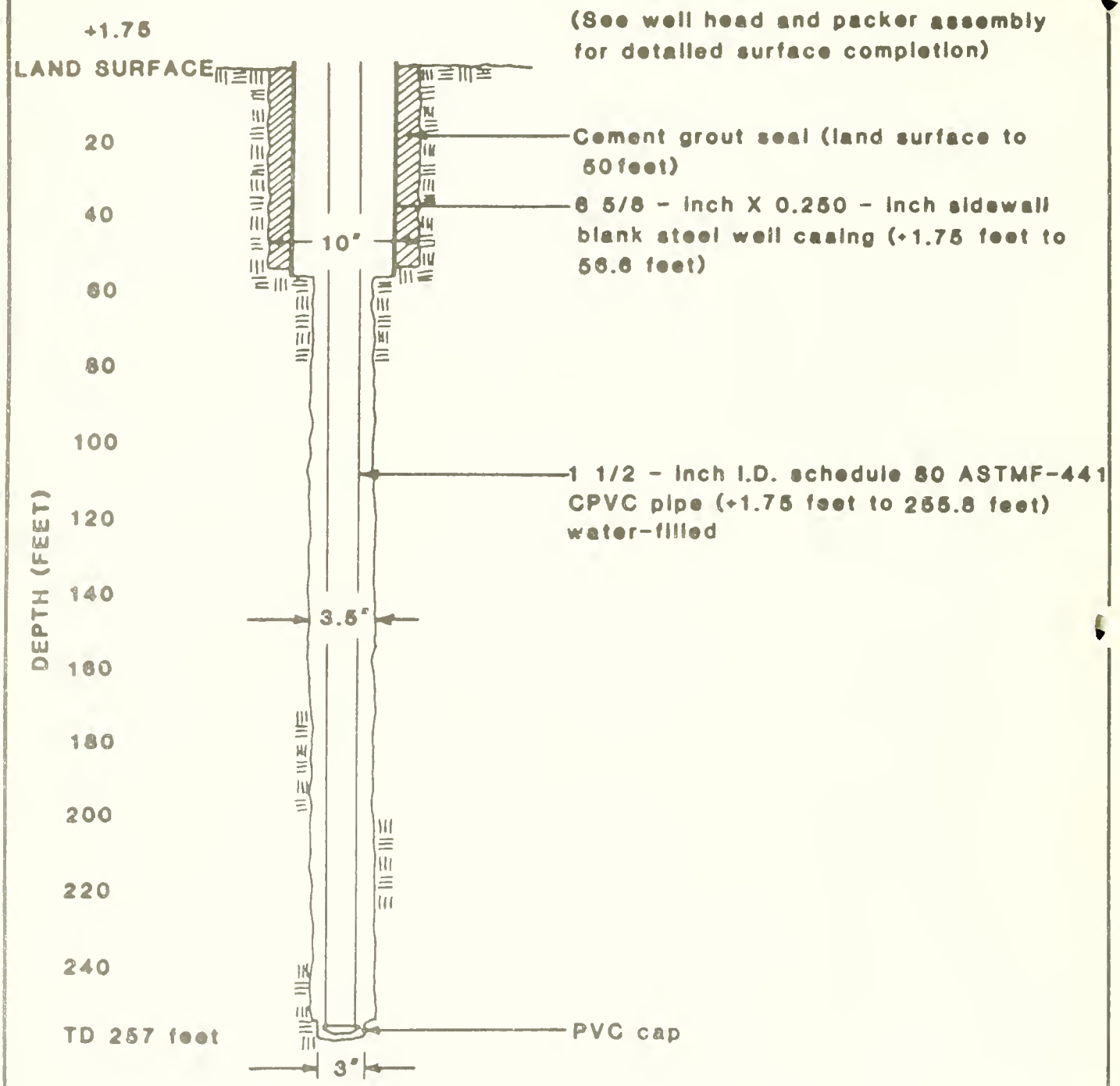


Figure 1. Construction diagram for CAT-1

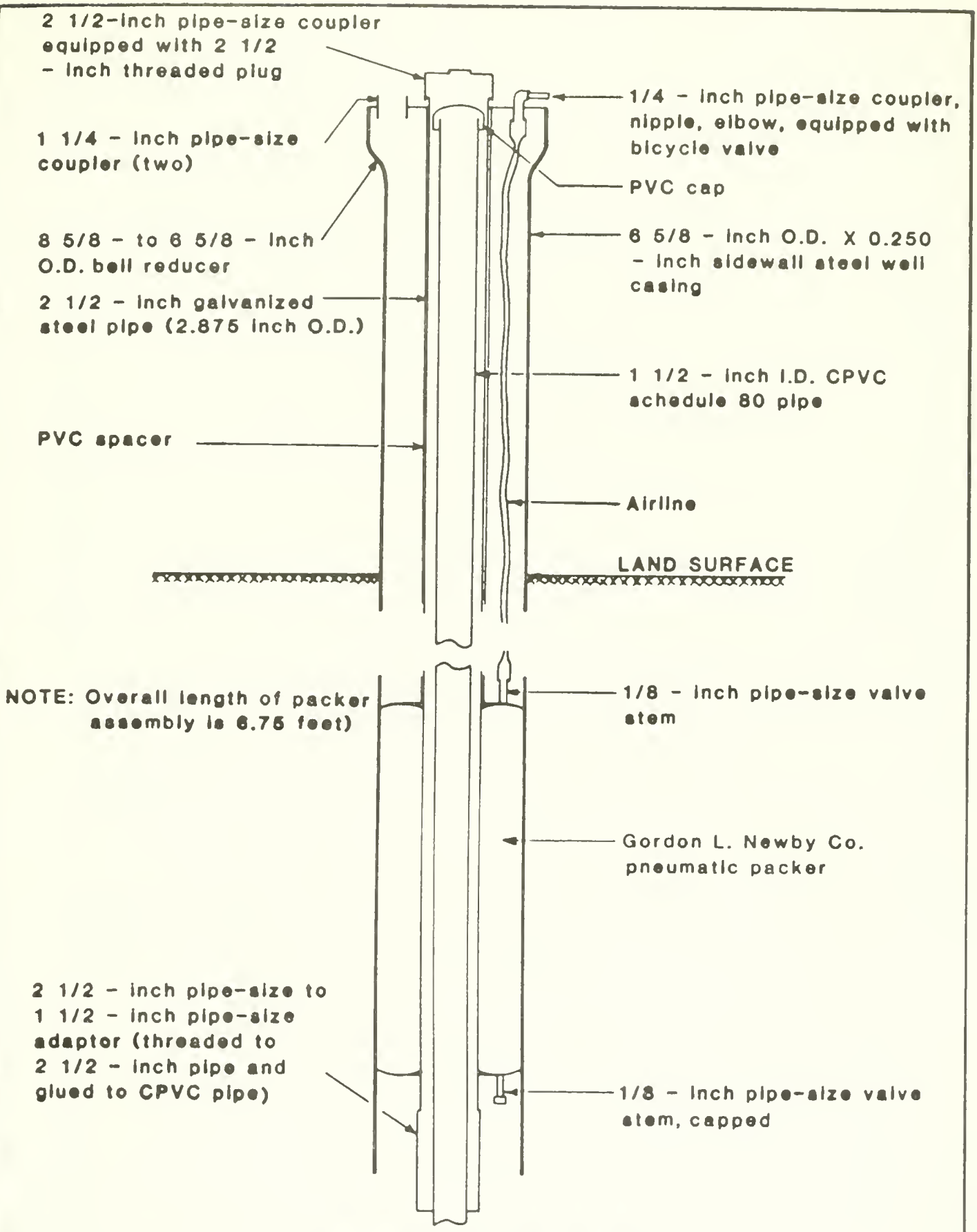
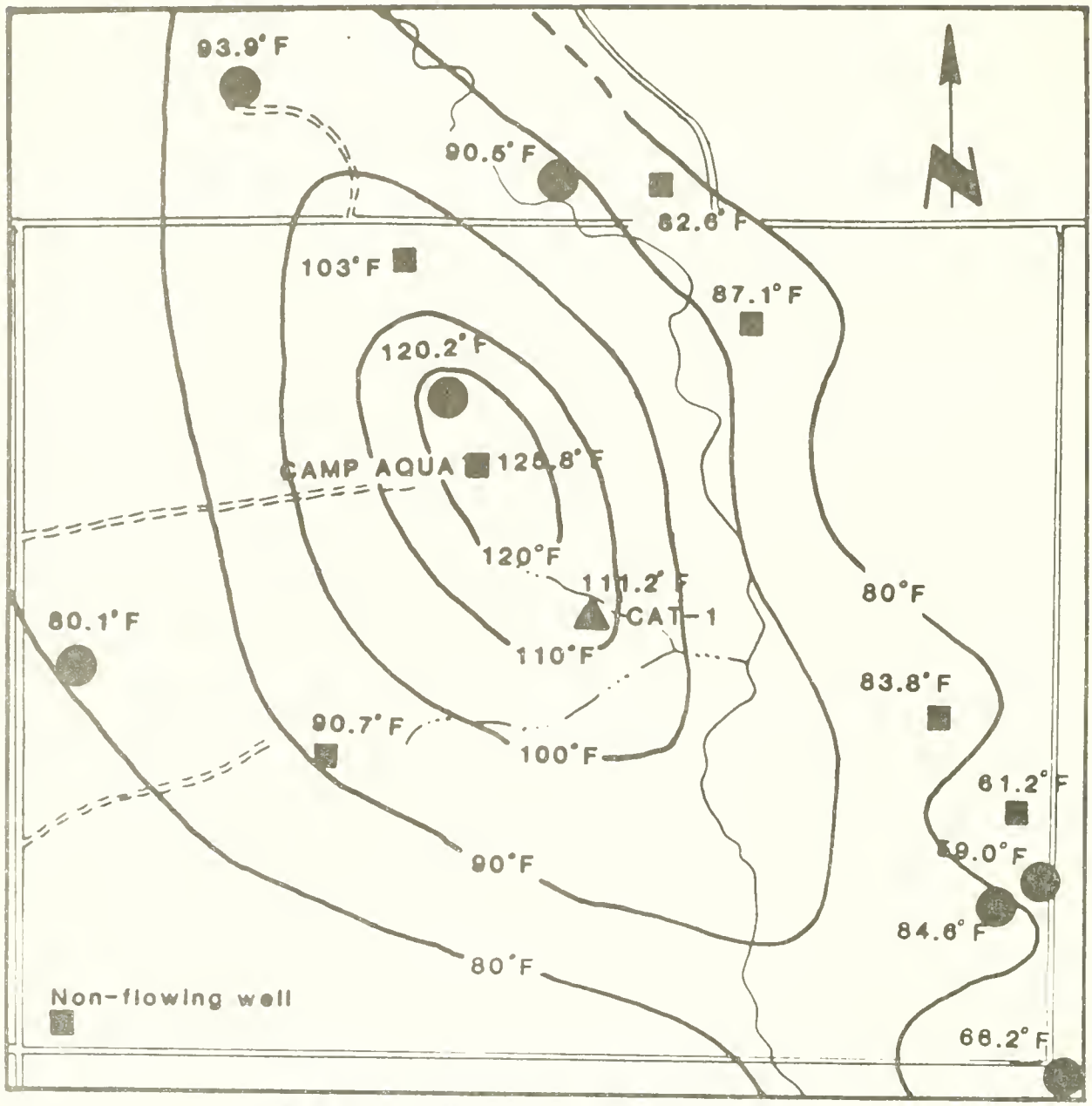


Figure 2. Well head and packer assembly



Prepared by WEN INC., Febuary 1982

● - Well which was T-logged 01/07/82

■ - Well which was NOT T-logged

▲ - WEN INC. temperature gradient hole

Example: 85 F - Outflow temperature

Figure 3. Exploration hole location and revised thermal contours of the artesian aquifer in the vicinity of Camp Aqua

LOG OF BOREHOLE

BOREHOLE CAT-1 PAGE 1 of 1

LOC. or COORDS. SE¼ SW¼ NE¼ Sec. 29, T.22N., R.23W.	DRILLER NORTHERN TESTING LAB		START / FINISH
GROUND ELEV. 2754	GREAT FALLS, MT	DATE	01/26/82 / 01/26/82
TOTAL DEPTH 258 ft	RIG MOBILE B-50	TIME	1200 / 0900
BOREHOLE DIAM Nominal 10" Nominal 4" Nominal 3"	BIT(S) 9" auger, 3½" drag, 2 15/16" tricone	GEOPHYS LOG	YES x NO
	FLUID WATER	HOW LEFT	see constr 123

LOCATION Camp Aqua, Lake Co. MT

LOGGED BY DCB

PROJECT HOT SPRINGS, MT (JACKOLA ENGINEERING

DEPTH	PENETRATE (ft/min)	CIRC. RET.	CIRC. LOSS	A-LIFT Q (gpm)	MATERIAL	SYMBOL	DESCRIPTION AND COMMENTS
				0	sand		brown silty sand (loose)
							Δ to clay @ 20'
							light brown clay
50							switch to mud rotary @ 55'
	1.5				clay & silty clay		formation cuttings are totally washed out
100							color change to mud brown clay & silty clay @ ~100'
							occassional fine sand stringer
							clay balls (<2mm) in returns
150	1.2						tight clay bed 145-148'
							formation Δ to (varvely) grey & brown clay
200	1.5						occassional sand-sized grains
							formation Δ to predominantly grey clay ~220'
							indurated clay "cap rock" 238-241 ft
250	0.5			flowing	sand, gravel & cobbles		blue green sand, cobbles & gravel of claystone, metamorphic rx & quartzite
							Artesian flow of 175 gpm

Jackola Engineering Co.

January 20, 1982

Department of Natural Resources
and Conservation
Attention: Mr. Jim Rehbein
Water Rights Bureau
P. O. Box 860
Kalispell, MT 59901

Dear Sir:

In followup of our recent discussion, attached is preliminary detail being planned for observation at Camp Aqua near Hot Springs, Montana. The information was transmitted by Teletype and the copies are not real clear. If you have any questions, please give me a call.

Our current schedule suggests that we could begin this drilling on Tuesday, January 26, 1982.

Sincerely,

Thor A. Jackola

TAJ:sh

Encl

575 SUNSET BOULEVARD - P.O. BOX 1134 - KALISPELL, MONTANA 59901 - 406-755-3208

Jackola Engineering Co.

January 20, 1982

Department of Natural Resources
and Conservation
Energy Division
Attention: Mr. Jeff Birkby
32 South Ewing
Helena, MT 59624

Dear Sir:

Attached is preliminary detail concerning the observation well development at the Hot Springs site. Information was transmitted by Telex and the copies are not really clear. If you have any questions, please give me a call.

Current schedule suggests that the drilling could start Tuesday, January 26, 1982. I might add that we are using 1 1/2" Schedule 80CPVC pipe for the probe tube which has a 210°F. spec capability at 75 psi pressure. At 160°F it has a 188 psi pressure. We felt it was necessary to go to this capability in pipe because of the potential temperatures involved.

Sincerely,

Thor A. Jackola

TAJ:sh

Encl

575 SUNSET BOULEVARD - P.O. BOX 1134 - KALISPELL, MONTANA 59901 - 406-755-3208

Northern Testing Laboratories
CONSULTING ENGINEERS

Great Falls MT
Billings MT
Boise ID
Pocatello, ID
Casper WY
Tri Cities WA

EXHIBIT B

January 21, 1982

Jackola Engineering
P. O. Box 1134
Kalispell, Montana 59901

ATTENTION: Mr. Thor Jackola, P.E.

SUBJECT: Observation Well Installation
Hot Springs Development
Hot Springs, Montana

Gentlemen:

We are pleased to work with you in installing observation wells at the proposed Hot Springs Development.

Project Description

We understand that we are to install two, or possibly three, observation wells to depths on the order of 250 feet. The wells are to tap a deep, geothermal aquifer that may be under artesian pressure. We further understand that we are to supply a drill rig, crew, and necessary drilling equipment; the field operation will be supervised by your hydrogeologist, and we will be available for consultation during the project. Discussions with you indicate that you will supply the necessary well materials, including those necessary to seal off the deep aquifer from shallow groundwaters.

Anticipated Subsurface Conditions

Based on our knowledge of this general area, we have developed an estimated fee schedule assuming the subsoils will consist of lacustrine silts and clays, with occasional sand layers overlying the aquifer.

Scope of Services

We will provide the necessary drilling equipment, drilling personnel, and engineering consultation for completion of the project as described above.

We may wish to sample the lakebed sediments at various intervals; time spent for such sampling will be deducted from your project costs.

Specializing in:

- Geotechnical Engineering
- Quality Control of Construction
- Construction Observation and Management
- Coal Analysis and Mining-Related Soils Analysis
- Chemical and Environmental Consulting Services

528 Smelter Avenue • P.O. Box 951 • Great Falls, Montana 59403 • 406-453-1641

Cost Estimate

Our fee for the investigations and report, as outlined above, will be in accordance with the attached unit price schedule. We expect the total cost of this project (for two wells installed within the three to four days per well estimate) will be in the range of $7500 to $8500. This cost includes a field mobilization charge which will be adjusted if economies can be achieved in connection with other work underway in your area.

If this description of services is in accordance with your understanding of the project, please sign the enclosed agreement and return it to us. As discussed, we will mobilize to the site on January 25, 1982, and be prepared to begin drilling the following day.

We look forward to working with you on this project.

Very truly yours,

Leland J. Walker, P.E.

LJW/cml

Enclosure
In duplicate

EXHIBIT A

Unit Price Schedule
For
Geotechnical Engineering Services

1. Mobilization of drill rig, crew, and engineer or geologist to jobsite, lump sum.....$1245.00

2. Provide drill rig and two-man crew, includes one-way travel to and from site, per hour..... 75.00

   Per diem, per man-day, actual lodging cost, plus..... 18.00/day

   Provide bits, drilling media, special sampling equipment, air compressor, water truck, water pump, equipment for site access or other auxiliary equipment to be invoiced at cost, plus 15% for handling.

3. Provide geotechnical engineer or geologist, for consultation:
   a. Project, Grade IV, per hour..... 47.50
   b. Assistant Project, Grade III, per hour..... 39.00

SECTION 4

SPECIFICATIONS - PRODUCTION WELL

551-811

GRANT NO. 551-811

WELL DEVELOPMENT PERMIT NO. 32593

AGREEMENT

CONSTRUCTION OF ONE WELL

THIS AGREEMENT, made this 29th day of March, 1982, by and between Jackola Engineering Co., hereinafter called "OWNER AUTHORITY" and Liberty Drilling & Pump Co. doing business as (an individual,) or (a partnership,) or (a corporation) hereinafter called "CONTRACTOR". WITNESSETH: That for and in consideration of the payments and agreements hereinafter mentioned:

1. The CONTRACTOR will commence and complete the construction of the well within 60 days of the Agreement date above.

2. The CONTRACTOR will furnish all of the material, supplies, tools, equipment, labor and other services necessary for the construction and completion of the PROJECT described herein.

3. The CONTRACTOR will commence the work required by the CONTRACT DOCUMENTS within 10 calendar days after the date of the AGREEMENT date above and will complete the same within 60 calendar days unless the period for completion is extended otherwise by the CONTRACT DOCUMENTS.

4. The CONTRACTOR agrees to perform all of the WORK described in the CONTRACT DOCUMENTS, comply with the terms therein for the sum based on the completed and executed unit price schedule, Section 1-A - one drilled well proposal form, but not to exceed $34,000.00.

5. The term "CONTRACT DOCUMENTS" means and includes the following:

   (A) Project Manual & Specifications, dated February 5, 1982, included Contractor executed and completed unit price schedule, dated March 5, 1982, all units of work performed will apply.

   (B) This CONTRACT AGREEMENT when executed by both Parties, constitutes a Notice of Award and Notice to Proceed.

   (C) General Conditions and General Requirements.

   (D) CHANGE ORDER, should it be required.

(E) Project Manual including SPECIFICATIONS prepared or issued by Jackola Engineering Co., Kalispell, Montana, dated February 5, 1982.

(F) ADDENDA: None.

(G) This work is being accomplished through a Grant from the State of Montana, Department of Natural Resources, Energy Division, and provisions of that Agreement and any amendments thereto, become part of this Agreement.

6. The OWNER AUTHORITY will pay the CONTRACTOR in the manner as set forth in the General Conditions per the unit price schedule for those items of work performed, such amounts as required by the CONTRACT DOCUMENTS, and calculated to a total amount due and payable at time of receipt of Grant Payment for the work but not to exceed $34,000.00.

7. This Agreement shall be binding upon all parties hereto and their respective heirs, executors, administrators, successors, and assigns.

IN WITNESS WHEREOF, the parties hereto have executed, or caused to be executed by their duly authorized officials, this Agreement in two (2) copies, each of which shall be deemed an original on the date first above written.

OWNER AUTHORITY:
JACKOLA ENGINEERING CO.

By: Thor A. Jackola
Duly Authorized Official

Name: Thor A. Jackola

Title: President

(SEAL)

ATTEST;

Name Sherley L. Hallesberg

Title

CONTRACTOR:

LIBERTY DRILLING & PUMP CO.

By: W. F. Osborne

Duly Authorized Official

Name: William F. Osborne

OWNER

Address: 3850 Highway 93 South,

Kalispell, Montana 59901

Montana Contractor's License No.

3375 - A

MONTANA WATER WELL CONTRACTORS

LICENSE NUMBER 52

(SEAL)

ATTEST:

Name Shirley L. Hallenberg

Title

PROJECT MANUAL

INCLUDING

SPECIFICATIONS

STATE OF MONTANA

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

FOR

GRANT NO. 551-811

WELL DEVELOPMENT

PERMIT #32593

LAKE COUNTY, MONTANA

SE 1/4, SW 1/4, NE 1/4, SEC. 29, T22N, R23W

CAMP AQUA SITE NEAR HOT SPRINGS, MONTANA

GRANTEE

AND

PREPARED BY

JACKOLA ENGINEERING CO.
P. O. BOX 1134
KALISPELL, MONTANA 59901

PHONE: 406/755-1268

DATE: FEBRUARY 5, 1982

GENERAL REQUIREMENTS

SECTION 1

GENERAL

a. The specifications are abbreviated, of streamline type, and frequently include incomplete sentences. The omission of words or phrases such as, "The Contractor shall", "in conformity with", "shall", "shall be", "as noted", "according to the plans", "a", "an", "the", and "all", are intentional. Omitted words or phrases shall be supplied by inference, in the same manner as they are in notes on the drawings. Titles and Headings are a part of the Specification, the same as the text of the article or paragraph.

b. "Provide" shall mean "furnish and install", or "furnish labor and materials required for installation, ready for use, and under the terms of the Contract Documents".

"As shown", "as indicated", "as detailed", "as noted", or words of similar import refer to Contract Documents.

"Selcted" means "as selected by the Owner's authorized representative.

"Approved" means "approved by the Owner's authorized representative.

"For approval" means "for the Owner's authorized representative's approval". "Owner" refers to Owner's authorized representative.

c. It shall be the responsibility of the Contractor to determine the extent and division of work between Contractor and Subcontractor.

d. Where specifications require a product to be installed by the manufacturer's representative or similar requirement, such requirement shall be strictly enforced to the Engineer's satisfaction.

e. The Contractor shall maintain a neat and orderly construction site and leave site clean, graded and all debris removed.

SCHEDULE OF DRAWINGS AND SPECIFICATIONS

a. DRAWINGS
   * Location
   * Well Head Assembly
   * Construction Diagram
   * Existing Well Logs in Area

b. SPECIFICATIONS
   * These specifications as indexed and bound.

SPECIAL CONDITIONS

a. SITE EXAMINATION

* Visit site, ascertain for himself all apparent conditions affecting the contract.

b. PERSONNEL AND EQUIPMENT

1. Maintain a construction force at site, including supervisors, mechanics, craftsmen and laborers, sufficient to expedite work.

2. Maintain construction equipment at site, in good condition, as necessary to expedite work.

3. A responsible member of Contractor's organization shall be at the site at all times while work is in progress.

c. UTILITIES

1. WATER

* The Contractor shall provide facilities for water for construction purposes.

2. ELECTRICITY

* The Contractor shall provide his own source and make prior to construction arrangements with utility company or occupant.

d. ACCESS TO SITE AND USE OF PREMISES

1. Access to site is granted to the well development contractor for the expressed purpose of performing the work for its construction and completion.

2. The Contractor shall consult with the present operator of the Spa [illegible] tion and not unreasonably hinder the operation of the Spa.

TESTING AND INSPECTION

a. Cost in inspection, sampling and testing shall be paid by Contractor to extent noted in each division of specifications. Results of tests shall be binding on the Contractor.

GENERAL CONDITIONS

1. SPECIFICATIONS AND DRAWINGS

These specifications are intended to be standard specifications intended for use in a number of different types of construction projects. Instructions to Bidders, Special Conditions, Plot Plans, Drawings, and Specifications applicable to each specific contract will govern over these standard specifications only when they call for different results.

Any work or material shown on the drawings, but not mentioned in the specifications or vice versa, or anything not expressly set forth in either but which is reasonably implied and required for a complete workmanlike job shall be furnished by Contractor as though specifically mentioned and shown in both without additional cost to the Owner.

2. INSURANCE

Contractor shall carry at his own expense, comprehensive insurance in the following amounts:

a. Manufacturer's and Contractor's Public Liability:
$100,000 for each person; $300,000 for each accident;
$100,000 for property damage, to cover Contractor's operations and Contractor's protective liability risk in respect to any Subcontractors.

b. Owner's Protective Liability:

$100,000 for each person; $300,000 for each accident;
$100,000 for property damage, to cover Owner's liability with respect to all operations carried out under this contract by Contractor and his Subcontractors.

c. Motor Vehicle Liability:

$100,000 for one person; $300,000 for one accident;
$100,000 for property damage.

d. Fire and Extended Coverage Insurance:

Contractor will protect his own tools and equipment.

Before starting the work the Contractor will require his insurance company to furnish evidence of his insurance to Owner and agrees to keep it in force continuously during the course of the work. All insurance policies or contracts shall require a ten days' advance written notice to Owner prior to cancellation or material alteration.

3. PERMITS AND ORDINANCES

Contractor shall obtain and pay for all permits, approvals and inspections legally required for any part of his work, and shall conform to all ordinances, laws and regulations affecting the work covered by his contract. Contractor shall furnish and maintain any bonds, sureties, and temporary deposits for construction purposes which may legally be required by governmental authorities, and bear all costs in connection therewith.

Contractor will furnish all necessary utilities until job is complete.

If any features of construction shown on Owner's plans do not conform to legal ordinances, statutes, or regulations, Contractor shall immediately notify Owner of such discrepancy; if the Contractor performs any work contrary to such legal requirements he shall bear all costs arising from the correction of such work.

When legal requirements require changes in the work as originally called for by the Drawings and Specifications, Contractor shall construct the work in accordance with such requirements without additional cost to Owner, and in no case shall these changes result in any kind or quality of work in any way inferior to that originally called for, or latest codes of the National Code of Fire Underwriters.

4. INSPECTIONS AND TESTING

All work and equipment shall be tested by accepted standard methods or as outlined in the Specifications and must be in perfect working condition when accepted by Owner.

Where inspection or testing is required by law, city or county agencies, or any other body, Contractor shall arrange and pay all costs and supply certificates to Owner.

5. TAXES

The contract sum and any agreed variation thereof, shall include all taxes imposed by law INCLUDING any sales tax.

6. SUB-CONTRACTS

Contractor will supervise the work of all subcontractors and be responsible for the coordination of their work.

7. INSPECTION OF WORK

Contractor shall permit and facilitate inspection of the work by Owner and public authorities at all times.

8. CHANGES

Any changes, additions, or deductions made in this contract will be authorized only by execution of "Extra or Credit to Contract" form by Owner and Contractor.

9. SAMPLES AND SHOP DRAWINGS

Contractor shall furnish for approval all samples as directed by the Drawings and Specifications.

When necessary in connection with manufactured or fabricated parts of the work, Contractor shall furnish promptly complete legible shop drawings, IN DUPLICATE, for approval and no such work shall be manufactured or installed until Owner approval in writing is obtained. Such approval shall not be an acceptance of any defective work or material or omission of any parts originally called for.

10. LAYOUT

Contractor shall be responsible for the accuracy of all lines and grades for all parts of the work. He shall do all field work necessary to lay out and maintain the work and make available to Owner all information to check the accuracy of such field work. Owner will provide by way of a registered engineer's survey, reference points and bench marks to start the work.

11. STORAGE OF MATERIALS AND EQUIPMENT

Contractor shall provide proper storage for all materials and equipment and be liable for any material or equipment which is lost, stolen, or damaged on job site, including material and equipment furnished by Owner.

12. QUALITY OF LABOR AND MATERIALS

All materials, unless otherwise specifically agreed, shall be new and of the best quality, obtainable under the respective grades called for. Contractor shall, during working hours, maintain a competent representative to direct the work and receive instructions from Owner. Contractor will perform the work in diligent and workmanlike manner.

13. ROYALTIES AND PATENTS

The Contractor shall pay all royalties and license fees. He shall defend all suits or claims for infringement of any patent rights and shall save Owner harmless from loss on account thereof. In the event the Contractor fails to obtain the above-mentioned royalties or license fees, Owner reserves the right to obtain and pay the necessary fees and charge Contractor for same.

14. USE OF PREMISES

Owner may use the well site or portions thereof when substantially completed so as not to hamper the work of the Contractor. Use of the premises does not constitute acceptance of the job.

15. SPECIAL WORK

The Owner reserves the right to have special work, outside the scope of this contract, done during the course of the work herein included. Contractor will allow other contractors site access and coordinate his work with their work.

16. OWNERSHIP OF DRAWINGS AND SPECIFICATIONS

All Drawings and Specifications are the property of Owner and shall be returned to Owner upon completion of the work.

17. GUARANTEES

Contractor agrees to make good, without cost to Owner, any defects in materials or workmanship which may develop within one year after completion and acceptance of the work. The provisions of this article shall apply to work done by subcontractors as well as to work done by direct employees of the Contractor.

18. OWNERSHIP OF GUARANTEES, ETC.

Contractor will retain all guarantees, installation directions, parts lists, etc., furnished with equipment and turn same over to Owner upon completion of the work.

19. OWNER'S RIGHT TO TERMINATE CONTRACT

Should the Contractor neglect to prosecute the work properly or fail to perform any provision of the contract; should the work be stopped by any public authority for a period of thirty days or more, through no fault of Owner, or should the work be stopped through act or neglect of the Contractor for a period of four days; or if progress proceeds at an unsatisfactory rate, in Owner's opinion; then and in such event Owner may, upon seven days' written notice to the Contractor, without prejudice to any other remedy available, make good the deficiencies and deduct the cost therof from the payment then or thereafter due to the Contractor, or, at Owner's option, terminate the Contract and take possession of all materials, tools, and appliances and complete the work by such means as Owner sees fit. If Owner's expense in so completing the work exceeds the unpaid balance of the Bid Price, the Contractor shall promptly pay the difference to Owner.

20. CONTRACTOR'S RIGHT TO TERMINATE CONTRACT

Contractor shall have all rights of termination of this Contract, and all remedies for breach hereof, as shall be provided by law in the state wherein the job is to be performed.

SECTION 1 - WELL SPECIFICATION

SECTION 1-1 - GENERAL

Sec. 1-1.1 - Scope of Work

The work to be done hereunder includes the furnishing of all labor, material, transportation, tools, supplies, plant, equipment and appurtenances, unless hereinafter specifically excepted, necessary for the complete and satisfactory construction, disinfection, and testing of the proposed water supply well described under Sec. 1-1.7.

Sec. 1-1.2 - Permits, Certificates, Laws and Ordinances

The contractor shall, at his own expense, procure all permits, certificates and licenses required of him by law for the execution of his work. He shall comply with all federal, state or local laws, ordinances or rules and regulations relating to the performance of the work.

Sec. 1-1.3 - Location

The well to be constructed hereunder is to be located at Camp Aqua, approximately 5 miles east of Hot Springs, Montana. See plan for well locations; however, verify location with Engineer before construction.

Sec. 1-1.4 - Local Conditions

Refer to attached well [illegible] ( ) for an indication of the formation to be expected. This information regarding sub-surface conditions is intended to assist the contractor in preparing his bid. However, the owner does not guarantee its accuracy, nor that it is necessarily [illegible] of [illegible] constructed hereunder, and the contractor shall satisfy himself regarding all local conditions affecting his work by personal investigations, and neither the information contained in this section nor that derived from maps or plans or from the owner or his agents or employees, shall act to relieve the contractor from any responsibility hereunder or from fulfilling any and all of the terms and requirements of his contract.

Sec. 1-1.5 - Boundaries of Work

The owner shall provide land or rights-of-way for the work specified in this contract and make suitable provisions for ingress and egress, and the contractor shall not enter on or occupy with men, tools, equipment or material, any ground outside the property of the owner without the written consent of the owner of such ground. Other contractors and employees or agents of the owner may for all necessary purposes enter upon the work and premises used by the contractor, and the contractor shall conduct his work so as not to impede unnecessarily any work being done by others on or adjacent to the site.

Sec. 1-1.6 - Protection of Site

Excepting as otherwise provided herein or as excepted by the owner, the contractor shall protect all structures, such as walks, pipelines, trees, shrubbery, and lawns during the progress of his work; shall, if so instructed by owner, remove from the site all cuttings, drillings, debris and unused materials; and shall, upon completion of the work, restore the site as nearly as possible to its original condition, including the replacement, at the contractor's sole expense, of any facility or landscaping which has been damaged beyond restoration to its original condition or destroyed. Water pumped from the well shall be conducted to a place where it will be possible to dispose of the water without damage to property or the creation of a nuisance.

Sec. 1-1.7 - General Description of Well

The completed wells are to consist of the following principal items:

A first section a minimum of 80 ft. depth to penetrate soil, sand, clay and gravel, extending from the surface of the ground. This section to be drilled 16"/18" in diameter and cased with 12.750" o.d. X .375 wall black steel casing. The top of this section shall have an eight inch (8") side diverter with valve and shall be capped with a welded metal plate and shall terminate at 24" above the ground elevation. The top plate shall be fitted with a 1" threaded coupling with nipple and 1" gate valve for a water bleed a 1/4" tap with 0-30 psi pressure gauge and a 2" threaded coupling or nipple centered with a plug or cap. The annular space between the 12" casing and the drilled hole shall be filled with grout with 1 1/2" min. thickness. If a temporary outer well casing is required for grouting, it shall be of such weight and design for the intended use to the depth required, and shall remain the property of the contractor.

A second section, extending down from the lower end of the upper section, is to be drilled 12"/10" in diameter. If the formation requires casing, such casing shall be 10.750" o.d. X .365" wall black steel casing. Contractor shall be prepared to perforate or furnish slotted well screen at any depth in the second section casing.

1-1.7 Cont'd

Special care and precautions shall be taken to properly plan and make the necessary preparations to properly handle the water from the drilled well. The water shall be conveyed by temporarily installed pipe to the most westerly stilling basin near the drill site. Special care shall be exercised to assure no erosion of the ground or embankments. All temporary construction shall be removed after completion of the well development. The diverter section at the casing top shall be properly positioned to allow flow in the correct direction to access the temporary pipeline. Joints and diverter connection shall be made to avoid leakage. The diverter 8" valve shall remain with the well.

Sec. 1-1.8 - Competent Workmen

The contractor shall employ only competent workmen for the execution of his work, and all such work shall be performed under the direct supervision of an experienced well driller satisfactory to the engineer.

SECTION 1-2 - CASINGS

Sec. 1-2.1 - Casings

Casings to be used hereunder as a part of the permanent well shall be of new black steel having the following minimum weights and dimensions: 12.750 in. casing 49.56 lb. per linear foot, 10.750 in. casing 40.48 lb. per linear foot. Casing shall be provided with drive shoes of approved type. Casings shall have welded joints.

If a temporary outer casing is required for construction purposes, it shall be 16.0" o.d., and of such weight and design as necessary to prevent entrance of sand and silt, to be reasonably watertight, and to permit its installation without distortion or rupture to the specified depth and dimension. Temporary casings need not be new or unused, and remain the property of the contractor.

SECTION 1-3 - DESCRIPTION OF WORK

The objective is to construct one production water well, which, by artesian flow, or, when equipped with permanent well pumps, will yield 500 gpm in continuous operation.

The contractor shall use his discretion and judgment, based on his drilling experience in the area and the yield required, to select equipment and methods of construction that best achieve the desired results. In any case, all requirements of these specifications and those of the revising authorities shall be met.

SECTION 1-4 - TESTING FOR YIELD AND DRAWDOWN

Sec. 1-4.1 - Time of Test

After the well has been completely constructed and cleaned out and its depth accurately measured, the contractor shall notify the engineer to that effect and shall make the necessary arrangements for conducting a final test. Besides this final test the engineer may order the contractor to make such additional pumping tests during and after construction as he deems necessary. All tests shall be run with similar equipment and in a like manner to that hereinafter described.

Sec. 1-4.2 - Test Pump

Artesian flow is anticipated at the drilling location. However, the contractor shall furnish and install, if necessary, pumping equipment capable of pumping to the required point of discharge a maximum of at least 750 gpm with satisfactory throttling devices.

The pumping unit shall be complete with prime mover of ample power, controls and appurtenances and shall be capable of being operated without interruption for a period of 48 hours.

Sec. 1-4.3 - Auxiliary Equipment

The contractor shall furnish all necessary discharge piping for the pumping unit, which shall be of sufficient size and length to conduct the water being pumped a distance of 125 ft. from the well, or sufficient distance so that discharge from developing and testing will allow drainage flow that will not return to the well. He shall also furnish, install and maintain equipment of approved size and type for measuring the flow of water; such equipment to be a weir box, orifice, or water meter. To measure the elevation of the water level in the well, an air line complete with gauge, hand pump, and check valve shall be provided. Unless otherwise permitted, the air line shall be securely fastened to the pumping unit and shall terminate approximately at the maximum desired pumping level stated in Sec. 1-4.2, but shall in no case be nearer than 2 ft. to the end of the suction pipe.

Sec. 1-4.4 - Duration of Test

Except as otherwise provided, the contractor shall furnish all labor, motive power, lubricating oil and other necessary materials, equipment, labor and supplies required and shall operate the pumping unit at such rates of discharge and for such periods of time as directed, excepting that the final test shall be run for a period of 24 hours, or until stabilized drawdown has continued for at least six hours when test pumped at 750 gpm. Accidental interruptions, may, if so agreed upon between the contractor and the engineer, be compensated for by correspondingly extending the time of the completion of the test run. After the completion of the final test the contractor shall

Sec. 1-4.4 - Duration of Test Cont'd

remove by bailing, sand pumping, or other methods any sand, stones, or other foreign material that may have become deposited in the well. Time stated for the duration of the final test is a minimum only, and the engineer reserves the right to require the contractor to extend such period of test, or to make additional tests.

Sec. 1-4.5 - Test Method

The contractor shall outline his proposed test method prior to testing and present it to the engineer for approval. This proposal shall include the type of test pump proposed, with the pump's capacity-head characteristics.

Sec. 1-4.6 - Data and Recordings

The contractor shall record and provide the following data at the starting and ending of each test cycle:

1) Artesian Pressure, and/or
2) Static water level
3) Depth of test pump
4) Time at starting and ending

During the testing, the contractor shall provide the following data, collected at a minimum of one hour intervals:

1) Artesian Flow Rate, and/or
2) Pumping rate
3) Pumping water level
4) Drawdown
5) Water recovery rate and levels.

SECTION 1-5.1 - GROUTING AND SEALING

Sec. 1-5.1 - Grouting Material

The annular space between the inner or protective casing and the outer casing or hole shall be filled with cement grout. Grout shall be proportioned of cement and the minimum quantity of water (not over 6 gal. per cubic foot of cement) required to give a mixture of such consistence that it can be forced through the grout pipes. The mixture, method of mixing, and consistency of grout shall be approved by the engineer.

Sec. 1-5.2 - Placement of Grout

Before proceeding with the placing of the grout, the contractor shall secure the engineer's approval of the method he proposes to use. No method will be approved that does not specify the

Sec. 1-5.2 - Placement of Grout Cont'd

forcing of grout from the bottom of the space to be grouted towards the surface. A suitable cement retainer, packer, or plug shall be provided at the bottom of the inner casing so that grout will not leak through into the bottom of the well. The grouting shall be done continuously and in such a manner as will insure the entire filling of the annular space in one operation. No drilling operations or other work in the well will be permitted within 72 hours after the grouting of casings. If quick-setting cement is used, this period may be reduced to 24 hours.

Sec. 1-5.3 - Grouting Liners

Where required by the engineer, liners shall be grouted. The method to be used shall be detailed by the contractor for the approval of the engineer.

SECTION 1-6 - TESTING FOR PLUMBNESS AND ALIGNMENT

Sec. 1-6.1 - Requirement to Test

All holes shall be constructed and all casing and liners set round, plumb, and true to line as defined herein. To demonstrate the compliance of his work with this requirement the contractor shall furnish all labor, tools and equipment and shall make the tests described herein in the manner prescribed by, and to the satisfaction of, the engineer. Tests for plumbness and alignment must be made after the complete construction of the well and before its acceptance. Additional tests, however, may be made by the contractor during the performance of the work. No specific payments shall be made by the owner for making these tests.

Sec. 1-6.2 - Description of Test

Plumbness and alignment shall be tested by lowering into the well to a depth equal to that of the final permanent well pump setting a section of pipe 40 ft. long or a dummy of the same length. The outer diameter of the plumb shall not be more than 1/2 in. smaller than the diameter of that part of the casing or hole being tested. If a dummy is used, it shall consist of a rigid spindle with three rungs, each ring being 12 in. wide. The rings shall be truly cylindrical and shall be spaced one at each end of the dummy and one ring in the center thereof. The central member of the dummy shall be rigid so that it will maintain the alignment of the axes of the rings.

Sec. 1-6.3 - Requirements for Plumbness and Alignment

Should the plumb or dummy fail to move freely throughout the length of the casing or hole to a depth equal to that of the final permanent well pump setting or should the well vary from the vertical in excess of two-thirds the smallest inside diameter of that part of the well being tested per 100 ft. of depth, or beyond limitations of this test, the plumbness and alignment of the well shall be corrected by the contractor at his own expense. Should the contractor fail to correct such faulty alignment or plumbness, the engineer may refuse to accept the well. The engineer may waive the requirements of this paragraph for plumbness if, in his judgment: (a) the contractor has exercised all possible care in constructing the well and the defect is due to circumstances beyond his control; (b) the utility of the completed well will not be materially affected; (c) the cost of necessary remedial measures will be excessive. In no event will the provisions of this paragraph with respect to alignment be waived.

SECTION 1-7 - DISINFECTION AND WATER QUALITY

Sec. 1-7.1 - Time of Disinfection

After the well has been completely constructed, it shall be thoroughly cleaned of all foreign substances, including tools, timbers, rope, debris of any kind, cement, oil, grease, joint dope, and scum. The casing pipe shall be thoroughly swabbed, using alkalis if necessary, to remove oil, grease, or joint dope. The well shall be disinfected with a chlorine solution after completion of work, if a substantial period elapses prior to test pumping or placement of permanent well pump, and shall be disinfected after placement of permanent well pump.

Sec. 1-7.2 - Chlorine Solution

The chlorine solution used for disinfecting the well shall be of such volume and strength and shall be so applied that a concentration of at least 50 ppm of chlorine shall be obtained in all parts of the well. Chlorine solution shall be prepared and applied in accordance with the directions of, and to the satisfaction of, the engineer, and shall remain in the well for a period of at least two hours.

Sec. 1-7.3 - Requirements for Disinfection of Test Pump

In the event that the test pump is installed after the well has been disinfected, all exterior parts of the test pump coming in contact with the water shall be dusted with a chlorine compound as directed by the engineer.

Sec. 1-7.4 Analysis of Disinfected Well Water

After disinfection, one or more water samples shall be submitted to a laboratory satisfactory to the reviewing agency for microbiological analysis with satisfactory results reported to the agency and the engineer prior to placing the well into service.

Sec. 1-7.5 - Physical and Chemical Quality

The well water shall be examined for applicable physical and chemical characteristics by tests of a representative sample in a laboratory satisfactory to the reviewing authority, with the results reported to the authority and the engineer. Samples shall be collected at the conclusion of the test pumping procedure and examined as soon as possible. Field determinations of physical and chemical constituents or special sampling procedures may be required by the reviewing authority.

Sec. 1-7.6 - Radiological Quality

Representative well water samples shall be examined and tested for radiological activity in a laboratory satisfactory to the reviewing authority with results reported to the agency and the engineer.

SECTION 1-7 - DISINFECTION AND WATER QUALITY

Sec. 1-7.1 - Time of Disinfection

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Representative well water samples shall be examined and tested for radiological activity in a laboratory satisfactory to the reviewing authority with results reported to the agency and the engineer.

SECTION 1-8 - SAMPLES AND RECORDS

Sec. 1-8.1 - Samples of Formations

The contractor shall keep an accurate record of the elevation to which the water level stabilizes as each aquifer is encountered and of the location of the top and bottom of each stratum penetrated, and shall save and deliver to the engineer a sample taken from each 5 feet of drilling and at every change of formation.

Sec. 1-8.2 - Record of Casing Pipe

The contractor shall keep an exact record of the order in which each piece of pipe is installed in the well, identifying each by number, size, and length.

Sec. 1-8.3 - Record of Material Removed During Development

The total number of cubic feet of material removed from the well as a result of developing the well shall be recorded by the contractor.

Sec. 1-8.4 - Daily Reports

The contractor shall also submit a daily report describing the nature of material encountered, the work done during each day, including such items of work accomplished as depth drilled, casing set, the water level in the well at the beginning and end of each shift, and such other pertinent data as he is requested to record by the engineer.

SECTION 1-9 - PROTECTION OF QUALITY OF WATER

Sec. 1-9.1 - Precautions to Be Taken

The contractor shall take such precautions as are necessary or as may be required permanently to prevent contaminated water or water having undesirable physical or chemical characteristics from entering, through the opening made by the contractor in drilling the well, the stratum from which the well is to draw its supply. He shall also take all necessary precautions during the construction period to prevent contaminated water, gasoline, or any other contaminant from entering the well, either through the opening or by seepage through the ground surface.

Sec. 1-9.2 - Corrective Work

In the event that the well becomes contaminated or that water having undesirable physical or chemical characteristics enters the well because of the neglect of the contractor, he shall, at his own expense, perform such work or supply such casings, seals, sterilizing agents or other material as may be necessary to eliminate the contamination or shut off the undesirable water.

Sec. 1-9.3 - Freedom From Sand and Turbidity

The contractor shall exercise extreme care in the performance of his work in order to prevent the breakdown or caving in of strata overlying that from which the water is to be drawn. He shall develop pump, or bail the well by such methods as may be approved by the engineer, until the water pumped from the well shall be substantially free from sand and until the turbidity is less than 5 mg/l as determined by the appropriate method for determining silica as outlined in Standard Methods for the Examination of Water and Wastewater, or as measured by a centrifugal sand separating meter, such as described in Jour. AWWA, 46:123 (Feb. 1954), or equivalent.

NOTE: In the case of a correctly constructed well that will not clear up despite the best efforts of the contractor, the requirements relative to quality of water contained in the last sentence may be waived.

SECTION 1-10 - TEMPORARY CAPPING

At all times during the progress of the work, the contractor shall protect the well in such manner as effectively to prevent either tampering with the well, or the entrance of foreign matter into it. Upon completion of the well the contractor shall provide and set a substantial screwed, flanged, or welded cap satisfactory to the engineer.

SECTION 1-11 - ABANDONMENT OF WELL

In the event that the contractor shall fail to sink the well to the depth specified or to such lesser depth as ordered by the engineer, or should he abandon the well because of loss of tools or for any other cause, he shall, if requested, and as directed by the engineer, fill the abandoned hole with clay or clay and concrete and remove the casing. Salvaged material furnished by the contractor shall remain his property.

SECTION 1-A - DRILLED WELL PROPOSAL FORM

UNIT PRICE BASIS

ITEM 1 - For setting up and removing equipment, the lump sum of THIRTY TWO HUNDRED AND EIGHTY dollars and NO cents ($ 3280.00).

ITEM 2 - For drilling, casing, and sealing approximately 80 ft. of 16" hole, with 12.75" o.d. casing, including any necessary couplings and shoes, the sum of ONE HUNDRED AND SIX dollars and EIGHTY NINE cents ($ 106.89) per linear foot.

ITEM 3 - For drilling approximately 195 ft. of bedrock of 12 in. uncased hole, the sum of THIRTY NINE dollars and NO cents ($ 39.00) per linear foot.

ITEM 3-A - For casing approximately 275 feet of 12" hole with 10.750" o.d. casing, including perforations as required, the sum of NINETEEN dollars and EIGHTY-FOUR cents ($ 19.84) per linear foot.

ITEM 4 - Furnish and install a ten inch telescope size Johnson stainless steel continuous slot well screen; Estimate 10', the sum of ONE HUNDRED AND NINETY FOUR dollars and NO cents ($ 194.00) per linear ft.

ITEM 5 - Perforating the ten inch casing in place, the sum of SEVENTY SIX dollars and NO cents ($ 76.00) per linear ft.

ITEM 6 - For grouting of annular space between 10.75 in. casing and 12" hole, TWENTY THREE [illegible] FORTY [illegible] 23.40

[illegible] SEVENTY FOUR [illegible] FIFTY 74.50

ITEM 7 - For setting up and removing test pump equipment, the [illegible] NINE HUNDRED AND FIFTY dollars and NO cents ($ 950.00) (BASED ON USING SHALLOW WELL CENTRIFUGAL PUMP)

ITEM 8 - For miscellaneous work and material, including tests [illegible] and plumbness and alignment, the lump sum of TWENTY SIX HUNDRED AND TWENTY FIVE dollars and NO cents ($ 2650.00).

In the event that the linear footages or time durations exceed or are [illegible] specified in Items 2, 3, 3-A, 4 & 5, the payment to the [illegible] shall be at the unit prices as bid.

BID SCHEDULE

The Bidder agrees that upon written acceptance of this bid, he will, within ten (10) days of receipt of such notice, execute a Contract and that he will provide acceptable Surety Bond or Bonds, as required.

The Owner reserves the right to reject any or all bids and to waive any informalities in the bidding.

The undersigned, if awarded the contract, agrees to complete all work within sixty (60) calendar days of beginning of construction, in accordance with the terms of the Contract.

Date: 3-5-82

LIBERTY DRILLING & PUMP CO

By: Thomas A Smith

Title: GENERAL MANAGER

Official Address:
Street or Box: 3850 HIGHWAY 93 SOUTH

City and State: KALISPELL, MT. Zip Code: 59901

Contractor's Montana License Number: 3375-A

WELL OWNER: Jay Gossett
Aurora, Illinois

WELL LOCATION: T. 22 N., R. 23 W., sec. 29 BADD

TOTAL DEPTH: 1002 feet

COMPLETION: +0.5'-104', 8 5/8" casing, no perforations, cemented in with nine sacks cement

+2.5'-264', 6 5/8" casing, no perforations, cemented in with two sacks cement

+2.5'-980', 2 3/8" liner, sealed bottom, no perforations, (for logging tools)

264'-1002', open hole 6 7/8"

T.D. 1002'

CONDENSED WELL LOG:

0-57'	Light to medium brown moist friable silt and silty clay
57'-138'	Dense rubbery medium to dark brown silty clay and clay
138'-140'	Dark brown clay, sharp angular gravel fragements
140'-180'	Dense rubbery medium to dark brown clay
180'-205'	Brown and grey-brown silty clay and clay
205'-239'	Grey to bluish-grey soft rubbery clay, thin sand seams
239'-240'	Thin hard cap rock
240'-264'	Gravel, interbedded sand
264'-1002'	Fine grained grey-green and blue-grey argillite with interbedded quartzite; major water-bearing fractures at

282' (5 gpm)

286' (20 gpm)

395' (15 gpm)

355' (90 gpm)

406'-409' (225 gpm)

430'-440' (40 gpm)

466'-468' (35 gpm)

529'-538', 570'-578' (350 gpm)

640'-690' (50 gpm)

SWL on 1/12/81 10.20 psi (+23.6 ft.)

TOTAL YIELD: 750-800 gal/min from bedrock (before 2" liner set) (no perforations in gravel)

500-750 gpm (after 2" liner set)

NOTE: Water producing zones in bedrock are hydrologically connected to the overlying gravel bed.

PUMPING WATER LEVEL: +20.6 ft. after 70 hrs. flow at 500 gpm.

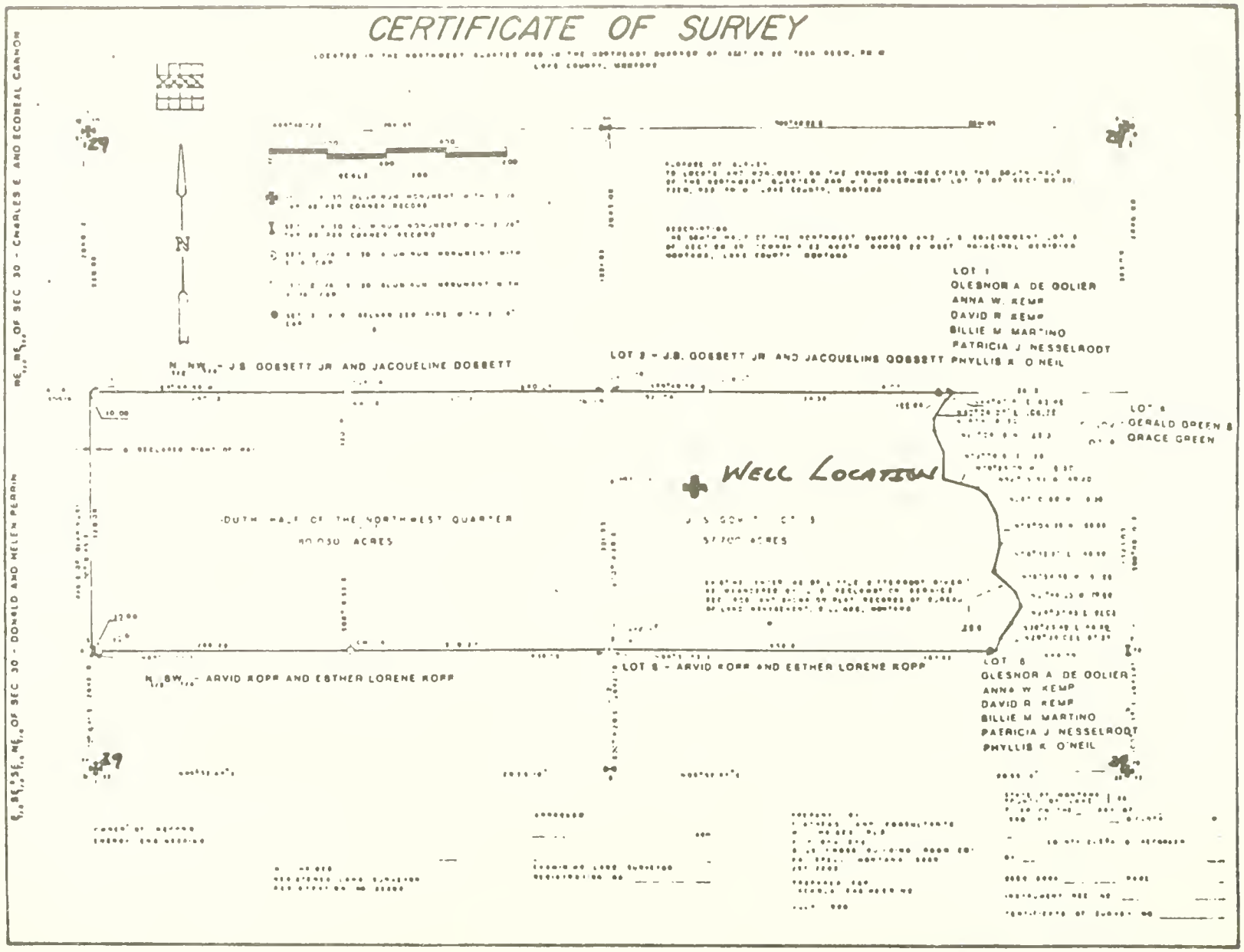
LOG OF BOREHOLE

BOREHOLE CAT-1 PAGE 1 of 1

LOC. or COORDS. SE¼ SW¼ NE¼ Sec. 29, T.22N., R.23W.	DRILLER NORTHERN TESTING LAB		START / FINISH
GROUND ELEV. 2754	GREAT FALLS, MT	DATE	01/26/82 / 01/26/82
TOTAL DEPTH 258 ft	RIG MOBILE B-50	TIME	1200 / 0900
BOREHOLE DIAM Nominal 10" Nominal 4" Nominal 3"	BIT(S) 9" auger, 3½" drag, 2 [illegible] 16 [illegible]	GEOPHYS LOG	YES x NO
	FLUID WATER	HOW LEFT	see constr 103

LOCATION [illegible] LOGGED BY [illegible]

DEPTH	PENETRATE (ft/min)	CIRC. RET.	CIRC. LOSS	A-LIFT Q (gpm)	MATERIAL	SYMBOL	DESCRIPTION AND COMMENTS
				0	sand		brown silty sand ([illegible])
							Δ to clay @ 20'
							light brown clay
50							switch to mud rotary @ 55'
	1.5				clay & silty clay		formation cuttings are totally washed out
100							color change to med brown clay & silty clay @ 100
							occasional fine sand stringer
							clay balls (<2mm) in returns
150	[illegible]						light clay bed 115-146'
							[illegible]
[illegible]	[illegible]						[illegible]
							[illegible] Δ to predominantly green clay ~ 220
							indurated [illegible] 238-241 ft
250	[illegible]			flowing	sand, gravel & cobbles	[illegible]	blue green sand, cobbles & gravel of claystone, metamorphic [illegible] & quartzite
							[illegible] flow at 175 gpm


CERTIFICATE OF SURVEY
N
LOT 1
GLESNOR A. DE GOLIER
ANNA W. KEMP
DAVID R. KEMP
BILLIE M. MARTINO
PATRICIA J. NESSELRODT
PHYLLIS K. O'NEIL
LOT 2 - J.B. GOSSETT JR. AND JACQUELINE GOSSETT
N. NW. - J.B. GOSSETT JR. AND JACQUELINE GOSSETT
LOT 6
GERALD GREEN &
GRACE GREEN
WELL LOCATION
SOUTH HALF OF THE NORTHWEST QUARTER
LOT 5 - ARVID KOPP AND ESTHER LORENE KOPP
N. SW. - ARVID KOPP AND ESTHER LORENE KOPP
LOT 6
GLESNOR A. DE GOLIER
ANNA W. KEMP
DAVID R. KEMP
BILLIE M. MARTINO
PATRICIA J. NESSELRODT
PHYLLIS K. O'NEIL
NE. NE. OF SEC. 30 - CHARLES E. AND ECONEAL CANNON
E. SE. SE. NE. OF SEC. 30 - DONALD AND HELEN PERRIN

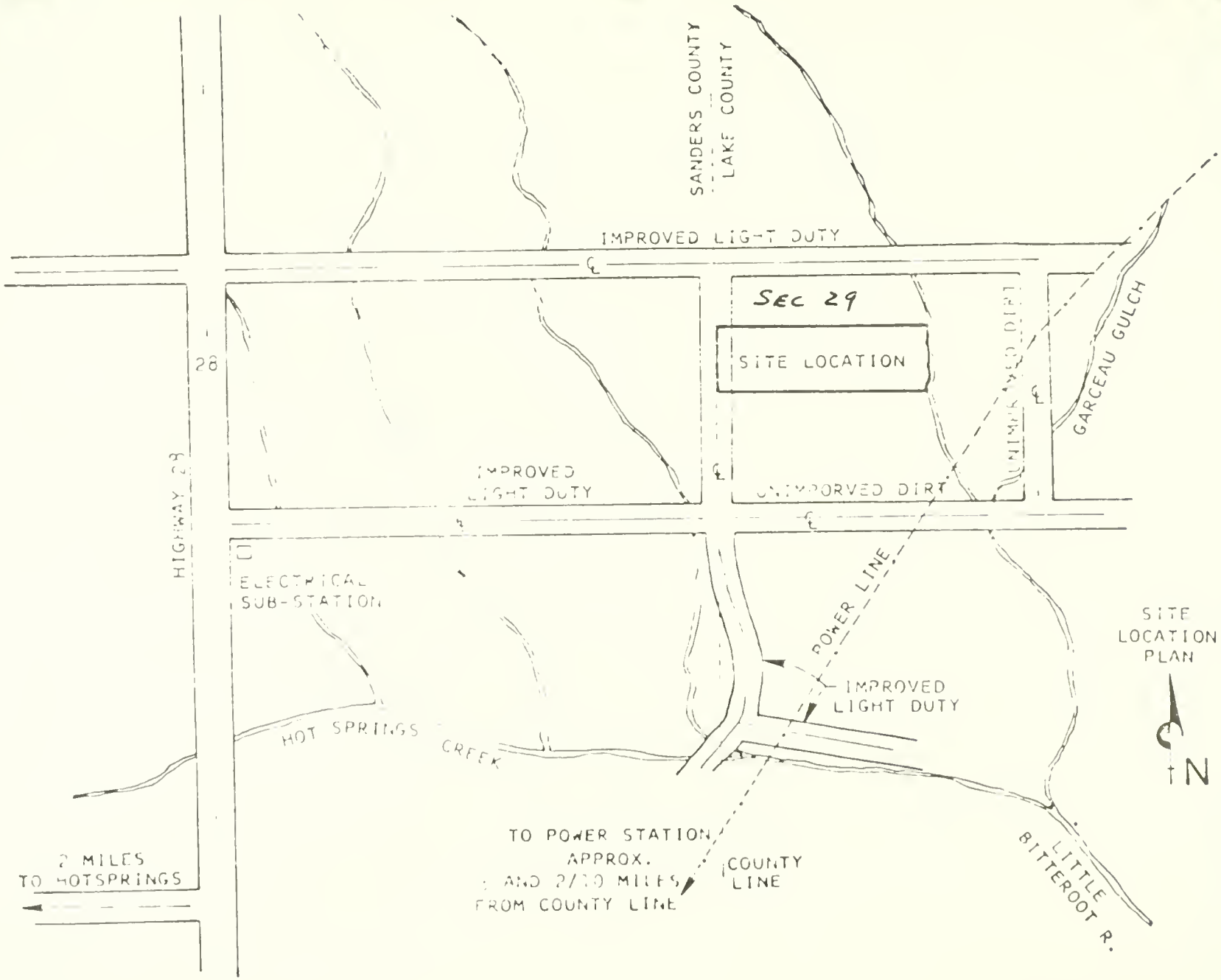


Figure 2-1. Site location

Jackola Engineering Co.

February 12, 1982

State of Montana
Dept. Natural Resources
and Conservation
32 South Ewing
Helena, MT 59620

Attention: Ms. Peggy Nelson

Re: Status Report
Grant #551-811

Dear Ms. Nelson:

In response to your letter dated January 27, 1982, attached is a status report and progress relating toward siting the geothermal production well.

We have also attached a preliminary specification on the production well drilling for your review. We are anxious to proceed with the well development pending DNRC approval to proceed. A permit #32593 has been assigned to the well development.

We will provide follow-up inserts for this report through the completion of the Grant effort. In addition, we will provide related data on further developments in connection with the resource as the project development takes place.

Kindly review the attached information and we would answer any questions you may have, to the best of our ability.

Very truly yours,

Thor A. Jackola

TAJ:sh

cc: Mr. Van Jamison
Mr. Jeff Birkby

575 SUNSET BOULEVARD - P.O. BOX 1134 - KALISPELL, MONTANA 59901 - 406-755-3208

Jackola Engineering Co.

February 19, 1982

Department of Natural Resources
and Conservation
Attention: Mr. Jim Rehbein
Water Rights Bureau
P.O. Box 860
Kalispell, MT 59901

Dear Sir:

Attached please find the preliminary specifications for the production well at Camp Aqua Hot Springs, Lake County, Montana for your review concerning the drilling under Permit No. 32593.

If you have any questions concerning the above, please give me a call.

Very truly yours,

Thor A. Jackola

cc: Mr. Jeff Birkby

TAJ:jl

encl.

575 SUNSET BOULEVARD - P.O. BOX 1134 - KALISPELL, MONTANA 59901 - 406-755-3208

SECTION 5

PRODUCTION WELL DRILLING DATA

551-811

Form No. 603 R2/81

File No. _____

WELL LOG REPORT

State law requires that this form be filed by the water well driller within 60 days after completion of the well.

1. WELL OWNER
Name: Jackola Engineering

2. CURRENT MAILING ADDRESS
575 Sunset Boulevard
Kalispell, MT 59901

3. WELL LOCATION
County: Lake
Township: 22 N/~~S~~ Range: 23 ~~E~~/W
SE ¼ SW ¼ NE ¼ Section: 29
Lot: _____ Block: _____
Subdivision: _____

4. PROPOSED USE Domestic ☐ Stock ☐ Irrigation ☐
Other ☒ specify: Industrial Plant

5. DRILLING METHOD _____ cable, _____ bored, _____ forward rotary, _____ reverse rotary, _____ jetted, X other (specify) Mud/air rotary

6. WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From (feet)	To (feet)	Perforations Mills Knife and/or Screen: Kind Size	From (feet)	To (feet)
[illegible]½"	12 3/4" OD x .375	0	99'4"			
12"	10 3/4" OD x .375	+3'	260'	3/8x 4"	250'	259'

Was casing left open end? X Yes ____ No
Was a packer or seal used? X Yes ____ No
If so, what material: Steel
Was the well gravel packed? ____ Yes X No
Was the well grouted? X Yes ____ No
To what depth? 99'4"
Material used in grouting: Cement grout
Well head completion: Pitless adapter ____ Yes X No
Top of casing 12 in. or greater above grade X Yes ____ No

7. WHAT IS THE TEMPERATURE OF THE WATER?
____ Degrees Fahrenheit
Measured Estimated

8. WATER LEVEL
Static water level: Flowing feet below land surface
If flowing; closed-in pressure: 8 - 12 lbs. psi
1160 gpm
Controlled by: X valve, _____ reducers, _____ other, (specify) _____

9. WELL TEST DATA _____ pump _____ bailer
X other, (specify) Air lift
Pumping level below land surface:
Est. 250 ft. after 19 hrs. pumping 1600 gpm
Flowing ft. after 48 hrs. pumping 1160 gpm

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes X No
If yes, how? _____

11. DATE COMPLETED 6/04/82

12. WELL LOG (Page 1 of 2)

Depth (ft.) From	To	Formation
0	4	Light brown silty clay.
4	11	Tan to light brown silty clay. Tough and rubbery.
11	39	Light brown to brown clay. Tough and rubbery.
39	57	Light brown to brown clay with thin layers of gray clay. Tough and rubbery.
57	116	Light brown to brown clay with thin layers of gray & dark brown clay. [illegible]
116	151	Medium to dark brown silty clay with layers of [illegible] clay. [illegible]
		[illegible]

(use separate sheet if necessary)

13. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Date: 7/11/82

Liberty Drilling and Pump Company
Firm Name: [illegible]
Kalispell, [illegible]
Address: [illegible]
Signature: [illegible] License No: [illegible]

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
32 SOUTH EWING HELENA, MONTANA 59620 449-3962
DNRC

WELL OWNER COPY

Well Log Report

Depth (ft.) From	To	Formation
151	203	Medium to dark brown silty clay with layers of blue-gray clay and seams of dark brown silt. Some rock fragments.
203	212	Light gray, blue, purple and gray clay. Some thin sand streaks with brown silt and small pebbles.
212	216	Sandy light gray to blue and purple clay.
216	234	Light gray, blue, purple and brown clay in alternate layers.
234	248	Sand and medium to fine gravel. Water.
248	259	Medium to coarse gravel. Some sand. Flowing water.
259	260	Rock.

LIBERTY DRILLING COMPANY

INDUSTRIAL DOMESTIC IRRIGATION WELLS

LICENSED, BONDED AND INSURED

3660 HIGHWAY 93 SOUTH
PH. 755-5644
KALISPELL, MONTANA 59901

July 14, 1982

Jackola Engineering
575 Sunset Boulevard
Kalispell, MT 59901

WELL LOG

Location: Camp Aqua Site near Hot Springs, Montana
SE¼, SW¼, NE¼, Section 29, Township 22 North, Range 23 West

Formation Log:

0	-	4	Light brown silty clay.
4	-	11	Tan to light brown silty clay. Tough and rubbery.
11	-	39	Light brown to brown clay. Tough and rubbery.
39	-	57	Light brown to brown clay with thin layers of gray clay. Tough and rubbery.
57	-	116	Light brown to brown clay with thin layers of gray and dark brown clay. Tough and rubbery.
116	-	151	Medium to dark brown silty clay with layers of blue-gray clay. Some small rock fragments.
151	-	203	Medium to dark brown silty clay with layers of blue-gray clay and seams of dark brown silt. Some rock fragments.
203	-	212	Light gray, blue, purple and gray clay. Some thin sand streaks with brown silt and small pebbles.
212	-	216	Sandy light gray to blue and purple clay.
216	-	234	Light gray, blue, purple and brown clay in alternate layers.
234	-	240	Light gray to blue-gray clay with gravel imbedded and thin layers of sand.
240	-	248	Sand and medium to fine gravel. Water.
248	-	259	Medium to coarse gravel. Some sand. Flowing water.
259	-	260	Rock.

Water Log:

Well flowed in excess of 1160 gallons per minute of 128.6 degree water through a four inch choke on a 20 hour test. Well produced in excess of 1600 gallons per minute through 19 hours of development with an air lift pump. Shut in pressure at completion of developing and test pumping was 8 to 12 pounds.

Casing Log:

The well is cased from surface to 99'4" with 12 3/4" O.D. x .375 wall black steel water well casing. The well is cased from 3' above surface to 260' with [illegible]4" x .365 wall black steel water well casing. A ten inch drive shoe is welded to the bottom of the ten inch casing.

Grouting Log:

A 17½" diameter hole was drilled from surface to 99'4" to accommodate 12 3/4" O.D. casing and provide an annulus for cement grout. This annulus was grouted with 95 sacks of cement grout to provide a surface seal and prevent flowing water from coming up around the 12 3/4" casing.

Perforating Log:

The 10 3/4" casing was perforated from 250' through 259' with a Mills knife with 3/8" x 4" slots. All water that is entering the well is coming through these perforations.

WILLIAM E. NORK, Inc.

CONSULTING SERVICES IN HYDROLOGY AND GEOLOGY

1026 W. First Street • Reno, Nevada 89503

Phone (702) 322-2604

June 1, 1982
82-231

RECEIVED JUN 10 1982

Mr. Thor Jackola
JACKOLA ENGINEERING COMPANY
P.O. Box 1134
Kalispell, MT 59901

RE: Temperature data collected during construction of production water-supply well at Camp Aqua.

Dear Mr. Jackola:

Temperature of the ground water derived from the recently drilled water-supply well at Camp Aqua was measured on Friday May 28, 1982. A Johnson-Keck DTM-75 temperature-logging device accurate to ±0.1° Fahrenheit was used to measure the temperature of the fluid at the well discharge and inside the casing. Results are summarized below:

1. Temperature of the discharge from the well was measured at 128.6° Fahrenheit. At the time measurements were taken, blank 10-3/4 inch O.D. casing had been driven to the bedrock-alluvium contact, a depth of about 261 feet below land surface. At this depth the artesian flow from the well was determined to be about 250 gallons per minute from seven feet above land surface measured with a 90° v-notch weir.

2. The temperature of the fluid in the borehole was measured once the casing was seated in the bedrock (a depth of 261.5 feet) and the artesian flow stopped. At a depth of 235 feet the temperature was logged at 135°F. The presence of the 10-inch D stabilizer in the casing prevented logging to T.D. Higher temperatures were recorded. However, due to a 10 second reaction time characteristic of the thermister coupled with cooling of the water within the borehole

after flowing ceased, the accuracy of those observations above 135°F are regarded as unreliable.

3. In addition to the water-supply well, temperatures were measured in CAT-1. The water within the closed 1¼-inch I.D. CPVC casing has been equilibrating with formation temperatures since February 1982 and should yield temperatures representative of the artesian aquifer at this locale. The temperature logged May 27, 1982 showed a maximum 119.1°F. Compared to a discharge temperature of 111.2°F measured at the well head upon completion of drilling last February.

The 128.6°F temperature measured from the discharge 5/28/82 is probably less than the temperature expected under normal operating conditions. Once the heat loss to the formation stabilizes the temperature of the discharge might increase slightly.

The performance test to be conducted on the well by the Montana Bureau of Mines and Geology later this week should yield temperatures which approach those expected during constant use.

If there are any questions do not hesitate to contact our office.

Sincerely,

WILLIAM E. NORK, INC.

Dale C. Bugenig

Dale C. Bugenig
Hydrogeologist

DCB:bh

Quarterly Report

Geothermal Studies in Montana

By

J.L. Sonderegger

C.J. Wideman

Period: January 1(?) to July 9, 1982

July 14, 1982

Geophysical work has been conducted at the Norris and White Sulphur Springs areas. Drilling arrangements were completed for drilling at Ennis. As of July 8, 1982, the well at Ennis was 653 feet deep, cased to 475 feet into a hornblende schist or gneiss. Production from the schist and underlying granite or quartzofeld-spathic gneiss, under rig air, is 340 gpm; artesian flow is 250 gpm (bucket and stop watch) at a temperature of 88°C (190°F).

A preliminary flow test was run on the new well at Camp Aqua; results for the Jackola well are 1100 gpm @ 121°F (49.4°C). The transmissivity of the aquifer is roughly 125,000 gallons per day per foot, based upon only one observation well.

ABRIDGED DAILY LOG
PRODUCTION WELL - CAMP AQUA
HOT SPRINGS, MONTANA

May 14, 15 & 17, 1982

Move equipment to site.

May 18, 1982

Set up drilling operation.
Equipment at site included rotary drill rig, 5 X 8 mud pump, backhoe/loader, water truck & flatbed truck.
Drill crew: Driller, 2 helpers & engineer.
17½ Hughes bit - 23'-6" drillability on first joint; 25'-9" overall length; K.B. = 2'-3".

May 19, 1982

Drill crew: Driller, 2 helpers & engineer.
Drilled to 23'-6" in Brown Clay; made connection and added 2' float sub drill assembly; 27'-9" overall length; 25'-6" drill bit; drilled to 97' in tough and rubbery brown clay.
Added one 5 X 6 mud pump.
Used 5 X 8 & 5 X 6 mud pumps to drill to clean hole.

May 20, 1982

Drill crew: Driller, 3 helpers & engineer.
Circulated and cleaned hole.
Ran casing to bottom and prepared for cement grouting. Casing size is 12" diameter.

May 21, 1982

Drill Crew: Driller, 2 helpers & engineer.
Cemented well with 90 sacks of cement.
Grouting depth 99'-4".

May 24, 1982

Drill crew: Driller, 2 helpers & engineer.
Filled top of hole to 2' down with 5 sacks of cement.
12" drilling assembly - 20'-9" overall length. K.B. = 2'-3".
Hit cement at 71'-6"; drilled out cement.
Drilled to 138'-6" in clay.

May 25, 1982

Drill crew: Driller, 2 helpers & engineer.
Drilled to 230 foot level.

May 26, 1982

Drill crew: Driller, rigger, 2 helpers & engineer.
Hit gravel @ 234' embedded in clay.
Drilled to 239' - stopped to run 10" casing.
Cased 60' and weather stopped operation for the day.

May 27, 1982

Drill crew: Driller, welder & 2 helpers.
Ran 10" casing to 228-7".
Weather stopped casing operation.

May 28, 1982

Drill crew: Driller, welder & 2 helpers.
Finished casing to 239'.
Rigged hammer and drove 10' to 249' depth.
Ran in 10" drilling assembly.
Drilled and drove casing to 260'.
Hit rock at 259'.
Flowing water @ 200 to 300 gpm.
Shut water off at sealing into rock.
Ten inch drive shoe welded at bottom of 10" casing.

June 1, 1982

Drill crew: Driller, welder & helper.
Prepared well head device at shop.
Moved device to job.
Cut 12" casing 2' below ;rade.

June 2, 1982

Drill crew: Driller, 2 helpers.
Finalized control head device.
Put on 8" valve and 6" discharge.
Set in mills knife and perforated from 259' back to 250'.
Removed perforator and put control head on to shut water off for Montana Tech people to install flow meter.
Opened for flow; Flow 1100 to 1150 gpm.

June 3, 1982

Drill crew: Driller, 2 helpers.
Installed temporary divertor pipe carry water to settling pond; 1160 gpm.
Removed some equipment from site.

June 4, 1982

Drill crew: Driller & helper.
Uncapped well and started bailing some sand and clears up quickly.
Closed top, shut well in and Montana Tech took flowmeter out of line.
Moved equipment off site.

June 7, 1982

Drill crew: Driller & helper.
Hauled 6" PVC winter control line to site, shaped site up for PVC line.

June 8, 1982

Drill crew: Driller, 2 helpers.
Installed 6" PVC line to settling pond.
Installed wellhead piping as requested at wellhead.
Moved off job.

SECTION 6

HYDROGEOLOGICAL INVESTIGATION

551-811

Jackola Engineering Co.

March 30, 1982

State of Montana
Department of Natural Resources
and Conservation
Energy Division
Attention: Mr. Van C. Jamison
32 South Ewing
Helena, MT 59620

Re: Grant #ARE 551811

Dear Sir:

I am in receipt of a copy of Mr. Donovan's comments concerning work performed on the above referenced Grant. Mr. Donovan has been very helpful in our efforts to put a project together at the Camp Aqua site. He offered assistance to Northern Testing Labs reporting in 1980 when that firm was performing geotechnical investigations for our firm at the site. Dr. Ohlgren and I visited with Mr. Donovan concerning the Camp Aqua project when he was in the area performing related work. We certainly are respectful of the work performed by MBMG and would hope that MBMG would feel the same about our efforts to promote a Montana industry at the Camp Aqua site.

We have made ourselves clear as to what our intents are at Camp Aqua, as that is the purchased site with which we have concerned ourselves. The investment has been substantial in the 136 acres of land coupled with the industrial planning cost. The assistance of the State of Montana DNRC in providing the needed development support is greatly appreciated. Currently, substantial investment of time and money has been expended attempting to bring about financing of the Agricultural By-Product Plant. The task is difficult and the most resourceful efforts of a lot of people in and mostly outside of Montana has been necessary to bring about consideration to review the project. We do not have a commitment today, nor do we know if and when a commitment may be possible. I might add that none of the problems appear to stem from the quality of the project or the presentation format but the competition for funds is very severe.

575 SUNSET BOULEVARD - P.O. BOX 1134 - KALISPELL, MONTANA 59901 - 406-755-3208

It may be that we were a little selfish to contain our investigation to establish the bounds of the resource within the Camp Aqua site. The CAT-1 was drilled to better establish this result and fill a blank area. The work was done to maximize information in the shortest period of time at least cost possible. I personally witnessed material of sand characteristic being augered from the hole beginning a very short distance below the surface, but our interests at this point were not the granulometry of this material. The CDVC pipe in CAT-1 hole will accomodate a slim diameter sonde and allow a neutron and/or gamma log run, if and when desired.

Regretfully, the data from the MBMG was not properly credited to its source. We erred there. The only defense we have here is that any information we have put out has been preliminary and you can be assured the final report will have that omission covered.

Our experts contend that the shallow temperature profile holes for this site could likely misguide follow-on exploration effort in that a shallow ground water circulation system exists. The sucrose-inversion method is "the state of the art" and is speculative at best. Past history of the type of procedure suggested by MBMG was used at a site similar to Camp Aqua in Nevada and results were misleading.

I was not aware that we had neglected to recognize MBMG efforts in the area since 1978 and that we were willfully ignoring MBMG in our work. My recollection suggests that we made considerable effort to have the MBMG well that was drilled on the Gossett property next door, drilled within the Camp Aqua property, where to our great surprise, it moved to the Gossett property. Our assumption was that Mr. Donovan felt the adjoining site was the proper location and had every right to locate it there. It well has been of benefit.

I would encourage MBMG to become involved to whatever level they like in any of the water related projects. We invite good and productive interchange of academia and industry. However, we do feel the need to respect the investment dollar and place maximum benefit to goals and less benefit to data development for the sake of data.

We are confident that the ethanol project will be successful and we feel we do possess the experience, knowledge and capability to design, construct, and operate the facility. The only barrier is to fund the project. We are not interested in involving ourselves in a match of intellectual savvy, but only to bring about the ultimate goal of a successful industrial development with the highest level of dedication we can muster. We will join hands with anyone with that goal. If you have any questions, please give me a call.

Very truly yours,

Thor A. Jackola

TAJ:sh

bcc: M. Murray, W. Nork

551-811

MONTANA BUREAU OF MINES AND GEOLOGY
MONTANA COLLEGE OF MINERAL SCIENCE AND TECHNOLOGY
BUTTE, MONTANA 59701
406/496-4166

RECEIVED
FEB 26 1982
MONT. DEPT. OF NATURAL RESOURCES & CONSERVATION

February 23, 1982

Mr. Jeff Birkby
Department of Natural Resources
and Conservation
Energy Division
32 South Ewing
Helena, Montana 59601

Dear Jeff:

Thanks for the review copy of the Bill Nork (WEN, Incorporated) report on the Campaqua area. Per your request, I am enclosing a few comments on their results. In order of your specific questions (see attached letter):

1) The drilling results and temperature of water encountered in test well CAT-1 are consistent with Montana Bureau of Mines and Geology data from this area; the temperature and geology encountered are what I would have predicted for this drilling site. Their temperature logging techniques seem quite adequate for temperature profiling, although their temperature profile data was not presented with this report. I disagree with their description of surface materials (0-20 ft.) as "sand". I believe that CAT-1 is very similar in elevation to LB-141 (test well drilled by MBMG in January 1981), is located on the same terrace, and should have encountered nearly identical geologic conditions in the upper 200 feet of section. In the LB-141 samples, observed both in the field and in the lab under the microscope, no material > 0.125 mm in diameter (fine sand or coarser) was encountered from 0-180 feet. Minor percentages of very fine sand (.06-.125 mm diameter) was encountered, and by far the majority of the material from 0-45 feet depth was in the silt fraction (.004-.06 mm diameter). While it is not impossible that conditions at two locations could be so different, I think it is unlikely; however, I would welcome any new information on the granulometry of this material that Nork may have collected. On the lowest terrace level (modern floodplain) of the Little Bitterroot River, these silty deposits are almost completely eroded away, and the material within 20 feet of the surface on this floodplain is somewhat finer silty clays and clays, similar to what is found below a depth of about 40 feet in CAT-1.

The only shortcoming I can see in the well testing program is that it would have been useful to have run geophysical logs (gamma and neutron) in CAT-1 before the drive casing was pulled, for comparison purposes with other wells we have studied in the area. I doubt there is sufficient

THE BUREAU OF MINES AND GEOLOGY WAS ESTABLISHED BY LAW IN 1919 AS A DEPARTMENT OF MONTANA COLLEGE OF MINERAL SCIENCE AND TECHNOLOGY TO PROMOTE EFFICIENT DEVELOPMENT OF MONTANA'S MINERAL RESOURCES BY GATHERING AND PUBLISHING INFORMATION ON THE GEOLOGY, TOPOGRAPHY, AND MINERAL DEPOSITS OF THE STATE, INCLUDING METALS, NON-METALS, COAL, OIL, GAS, AND UNDERGROUND WATER SUPPLY.

local variability in these Pleistocene lacustrine sediments that the logs from this well would have been very different from those from LB-141 or others in the area; however, this data is relatively fast and inexpensive to collect, if one has the equipment to do so as the MBMG and U.S. Geological Survey do. We were not invited to participate in the planning of CAT-1 by Jackola or Nork, nor were we invited to perform any geophysical or hydrogeological investigations on this well.

2) Nork's well did fill in a "blank spot", but, as I told both Jackola and Nork himself during our conference call last month, it was not a well location which had a high probability of success for obtaining hotter water than the existing Campaqua well (52° C). I also pointed out that, while there is no guarantee that hotter water exists in the gravel, silica geothermometry indicates that it probably does occur at a maximum temperature of at least 60° C, and that the best location to explore for this water lies primarily east of the Campaqua well and west of the Little Bitterroot River. This is the central part of the area shaded in Figure 11 (enclosed) of my August 1981 report of drilling and geophysical studies in the Campaqua area, a copy of which I sent to Bill Nork in December 1981. I note that the location of the CAT-1 hole falls outside the area, despite the fact that I expressed my pessimism at the chances for success of this well to Nork and Jackola before it was drilled.

I also note that temperatures on Nork's Figure 3, "Revised thermal contours of the artesian aquifer", are in all instances but two identical to the temperatures from Figure 11 of our report, mentioned above, converted from Centigrade to Fahrenheit units; and while I strongly encourage use of any or all of the data we produced, I believe (a) it would have been appropriate for Bill to cite data which he did not collect but gathered from other sources, and (b) it was highly inappropriate for him to interpret (draw contours on) our data without consulting us. Our temperature data consisted dominantly of well water temperatures, taken from wells of different diameter and flow characteristics, with attendant heat loss dependent on flow rate and residence time in the casing. They do not represent downhole temperature in the artesian aquifer, as Nork's figure suggests. For this reason we intentionally did not contour the data. Probably more significantly, Nork's map implicitly assumes that the Campaqua well taps the hottest water in the aquifer, an assumption which has not been proven by detailed exploration (gravity, thermal prospecting) and drilling in the critical area outlined in our report. It would be truly coincidental if the Campaqua well, located by chance in 1917, fortuitously struck the hottest water in the aquifer. I would therefore consider Nork's Figure 3 to represent work which is neither original nor validly interpreted.

3) Although their new data doesn't shed any additional light on the location for a production well, they still, as before, have the alternative either of pursuing a rational exploration program or of siting a well very close to the old Campaqua well, should they be satisfied with water of temperature 52° C or slightly higher. They should in fact be able to improve on this temperature somewhat with a new well at the same location,

both by producing a greater yield than the old well and thereby decreasing residence time and cooling in the well casing, and by completing the well in the bottom five feet of the gravel bed, which in our LB-141 temperature log was shown to be 1-2° C hotter than water at the top of the same aquifer. Drilling should continue until bedrock (or impermeable Tertiary sediments) are reached beneath the gravel; then completion could be effected using either well screen or open-bottom casing by pulling back the drive casing to no more than five feet above the base of the gravel. The gravel is so highly permeable that well screen would probably not be necessary, but could be used if it appears that the flow obtained during drilling is inadequate. They could, if desired, move slightly away (200 feet or less) from the old well, probably to the east or southeast, in an attempt to improve temperature slightly.

If they are serious regarding finding water > 52° C, an exploration program should be implemented involving at least:

a) detailed precision gravity measurements
b) detailed shallow temperature profiles

as I indicated both in our 1981 report and in several phone conversations with Nork and Thor Jackola. Such an exploration program would not have cost significantly more than CAT-1 and would have generated far more useful information. I disagree with their reasons for objecting to such techniques, although it may be true that Bill Nork himself does not have the equipment or experience to perform such surveys.

I hope these comments are of assistance to you in interpreting the Nork results. Please feel free to pass them along to Bill and Thor for their comments.

Throughout the MBMG involvement in and around the technical studies for water source development for the alcohol plant, I have been disappointed by an apparent unwillingness on the part of Messrs. Jackola and Nork to seriously consider our suggestions regarding exploration and development or to involve us in their studies at all, even at no cost to themselves. We have been performing geological studies in this area since 1978 and new geological information is of interest both to us and to those concerned with ground-water rights in the valley, including the Water Rights Division of DNRC. We believe our experience in the area and data we already have collected could contribute valuable knowledge to this project and help conserve the amount of state resources expended on it. In return for our assistance and advice, we have to date requested only cooperation and free exchange of all data collected. I recently told Thor we would be willing to perform the detailed gravity survey on the Campaqua site on MBMG time with his cooperation in leveling approximately 100 survey stations. While he initially appeared receptive and cooperative on the phone, I have not received any additional follow-up on this request. It is discouraging to me that the only cooperation I have had with Thor is for his consultant to have misapplied data taken from our report without the basic courtesy of citing the data and consulting us before he attempted to interpret it. Particularly in light of the fact that the project is being funded with state monies and carried out by an out-of-state consultant, I think that closer cooperation between DNRC grant recipients and the MBMG on water-related projects where we

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
ENERGY DIVISION

TED SCHWINDEN, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-3780

HELENA, MONTANA 59620

February 16, 1982

Mr. Joe Donovan
Montana Bureau of Minea
and Geology
Main Hall
Montana Tech
Butte, MT 59701

Joe:

Here's Nork's report on the Camp Aqua well. Let me know the following:

1. Did Nork test the well adequately?
2. Did the resulting data really fill in the "blank spot" in the southeast corner?
3. Does the resulting data justify their decision to site the production well?

Seems to me that they may have gained a little knowledge, but I don't know that they have enough information to draw that 110°F isotherm. I also don't follow their logic in siting the well south and east of the Camp Aqua well - am I missing something?

Sincerely,

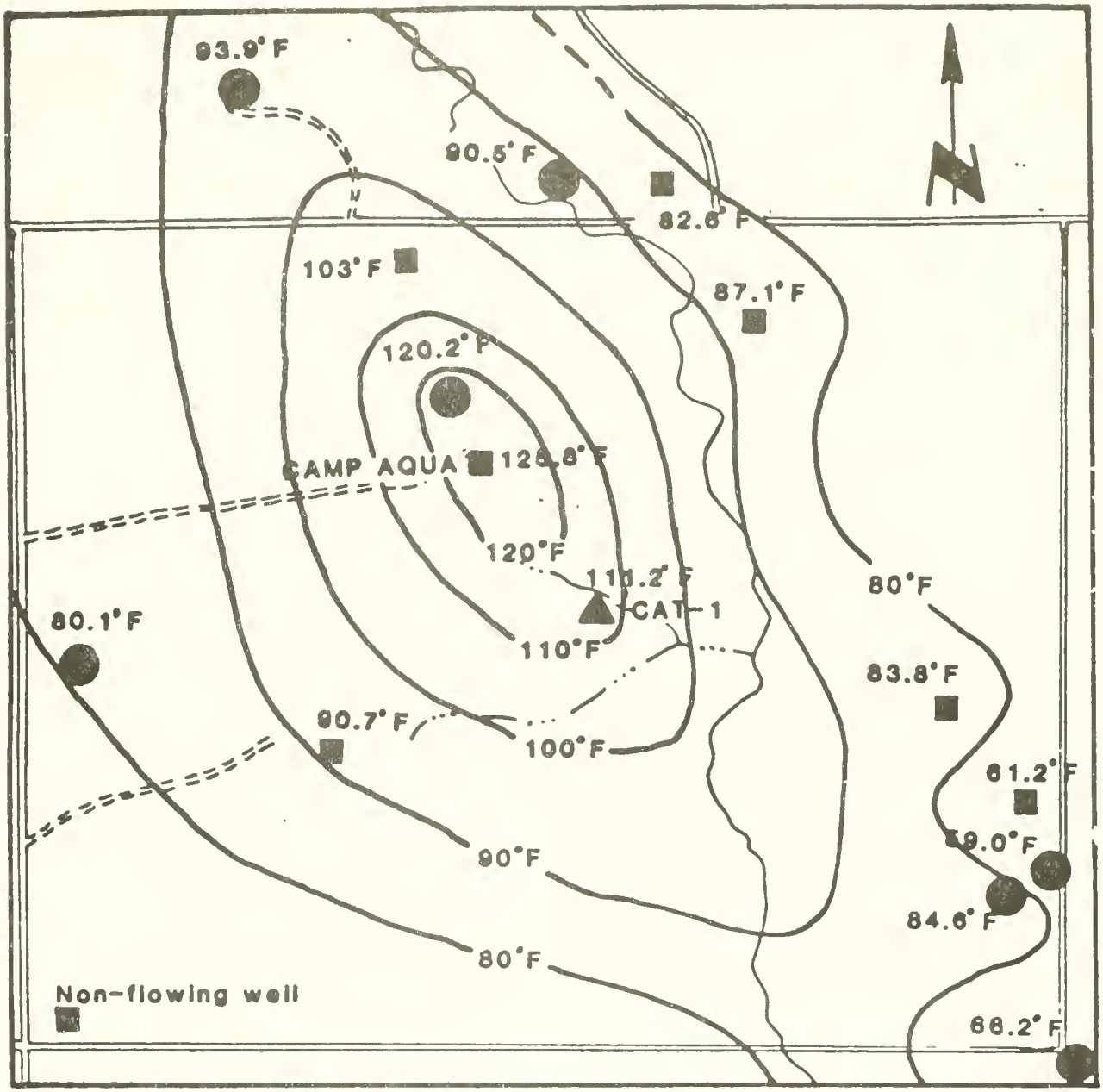
Jeff Birkby

Jeff Birkby
Geothermal Energy Specialist

JB/ld
Encl.

P.S. Could you check again on sending me a quantity of the Geothermal Resource Map? Thanks.

AN EQUAL OPPORTUNITY EMPLOYER



Prepared by WEN INC., Febuary 1982
(ref: Donovan and Sonderegger, 1981)

● - Well which was T-logged 01/07/82

■ - Well which was NOT T-logged

▲ - WEN INC. temperature gradient hole

Example: 85 F - Outflow temperature

Figure 3. Exploration hole location and revised thermal contours of the artesian aquifer in the vicinity of Camp Aqua

have expertise would improve the quality of the product of these grants and allow the department to allocate its grant money more productively. As it stands, I believe the Department has funded a test well that was not sited using sound hydrogeological and exploration principles.

I still am confident that the Campaqua ethanol plant project will be successful, if intelligent management of resource development and plant design is performed and if the plant's water demands are not in conflict with local water usage for irrigation.

Sincerely,

Joe Donovan

Joe Donovan
Hydrogeologist

JD:blm

Enclosure

cc: Charles Brasen, DNRC, Water Rights, Kalispell
Tom Bateridge, Confederated Kootenai-Salish Tribal Offices, Pablo
John L. Sonderegger, MBMG, Butte

WILLIAM E. NORK, Inc.

1026 W. First Street • Reno, Nevada 89503

CONSULTING SERVICES IN HYDROLOGY AND GEOLOGY
Phone (702) 322-2604

January 14, 1982
82-231

MEMORANDUM

TO: Thor Jackola
JACKOLA ENGINEERING

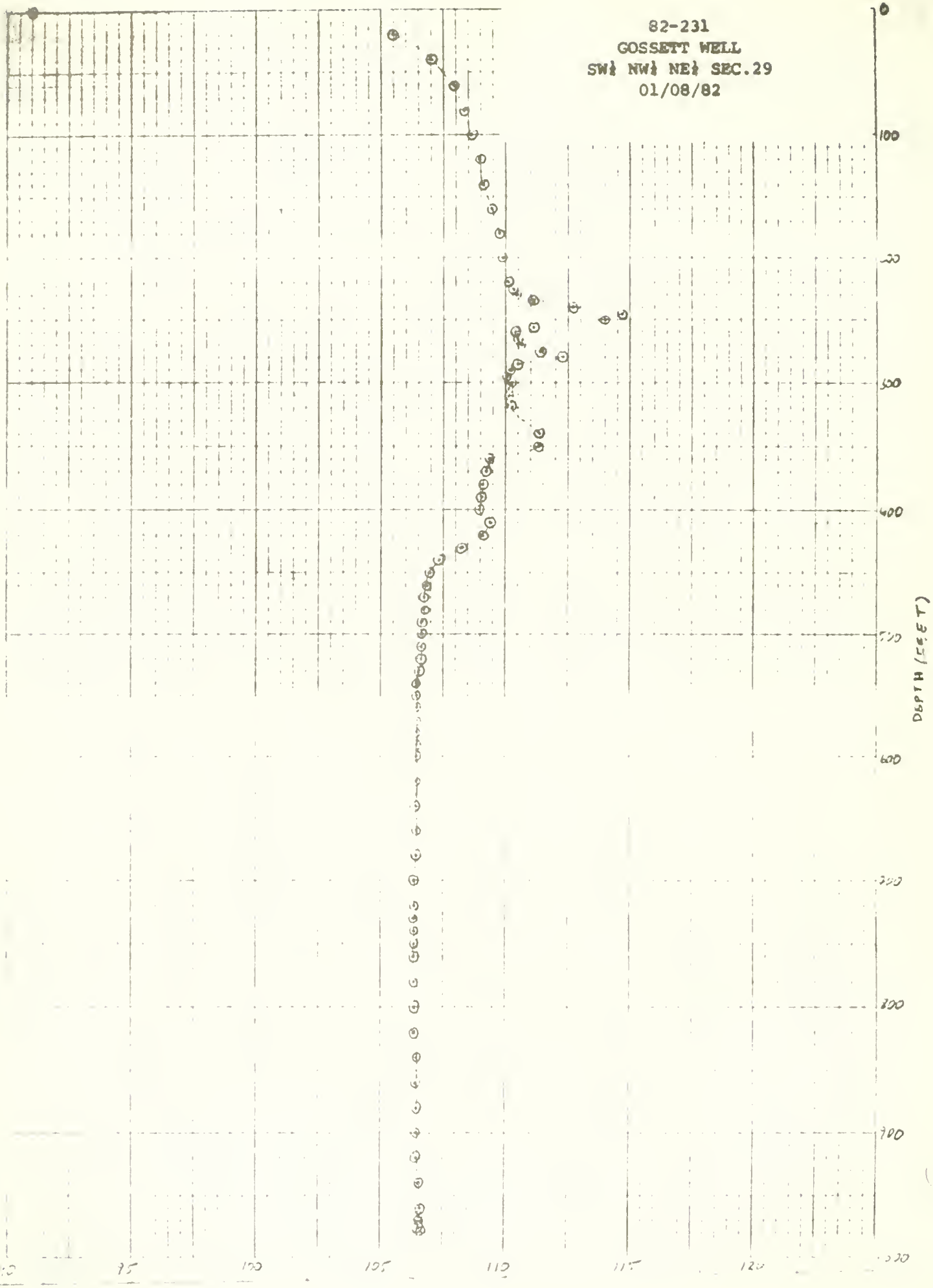
FROM: Dale C. Bugenig, Hydrogeologist DCB
WILLIAM E. NORK, INC.

RE: RESULTS OF TEMPERATURE LOG CONDUCTED IN THE "GOSSETT WELL" JANUARY 8, 1982, CAMP AQUA, LAKE COUNTY, MONTANA.

Upon receiving word from you at about 1350 hours 01/08/82 confirming that we were granted right-of-way to temperature log the Gossett Well, we immediately set out to do so. Prior to logging, the well was flowing via a three-quarter inch valve partially open and the gate valve also partially opened, with a combined flow of less than 20 gpm. These were closed to stop the flow during the logging procedure. The two-[illegible] to a depth of 98[illegible] feet. Upon completion of the log, the [illegible] was secured and left in the [illegible] in which it w[illegible] found -- both valves open slightly to prevent the well head [illegible] from freezing. Logging was completed by 1520 hours. A [illegible] copy of the log is attached.

Present were Burkhard Bohm, Bill Christensen, and myself.

DCB:bh


82-231
GOSSETT WELL
SW¼ NW¼ NE¼ SEC.29
01/08/82
DEPTH (FEET)
0
100
200
300
400
500
600
700
800
900
1000
95
100
105
110
115
120

WILLIAM E. NORK, Inc.

1026 W. First Street • Reno, Nevada 89503

CONSULTING SERVICES IN HYDROLOGY AND GEOLOGY
Phone (702) 322-2604

January 14, 1982
82-231

RECEIVED JAN 18 1982

Thor Jackola
JACKOLA ENGINEERING
P.O. Box 1134
Kalispell, MT 59901

RE: Camp Aqua

Dear Mr. Jackola:

Enclosed are two memoranda relating to the temperature logs run in the accessible flowing artesian wells in the vicinity of Camp Aqua. The temperature logs confirm that all hot waters enter the wells through the open casing bottoms and that significant cooling of the water either by mixing with cooler water or by conduction away from the well does not occur. A thermal contour map of temperatures measured from wells suggests that the hottest ground water is southeast of the Camp Aqua well. However, there are no wells in this area from which to collect temperature data to confirm the [illegible] thermal [illegible].

[illegible] our opinion that one to three [illegible] drilled into the artesian aquifer south and east of the existing Camp Aqua well. The first such hole should be drilled at the site initially selected by Bill Nork last December. The northwest-southeast trending axis of the isotherms passed through this site as well as a lineation trending east-northeast. Such holes may be relatively inexpensive and provide more reliable data than numerous shallow holes equipped with thermistors which sometimes yield unreliable results.

Prior to drilling these temperature holes, the Montana State Department of Water Resources (DWR) and Department of Energy (DOE) should be notified. The DWR may require a licensed well drilling contractor or drilling operator be involved to insure that artesian flows are properly contained. The DOE may feel slighted if they are not included in the selection process and may be ornery at later stages of the project.

If there are any questions do not hesitate to contact our office.

Sincerely,

WILLIAM E. NORK, INC.

Dale C Bugenig

Dale C. Bugenig
Hydrogeologist

DCB:bh

Enclosures (2)

WILLIAM E. NORK, Inc.

CONSULTING SERVICES IN HYDROLOGY AND GEOLOGY

1026 W. First Street • Reno, Nevada 89503

Phone (702) 322-2604

January 14, 1982
82-231

MEMORANDUM

TO: Thor Jackola
JACKOLA ENGINEERING

FROM: Dale C. Bugenig, Hydrogeologist DCB
WILLIAM E. NORK, INC.

RE: TEMPERATURE LOGGING OF FLOWING ARTESIAN WELLS IN THE VICINITY OF CAMP AQUA, LAKE COUNTY, MONTANA.

On January 7 and 8, 1982, ground water temperatures in a total of seven flowing artesian wells in the vicinity of Camp Aqua were logged by WILLIAM E. NORK, INC. personnel with the assistance of Bill Christensen. The objectives for logging were to measure bottom-hole temperature to determine in-situ temperature of the ground water, verify that the hot water entering the wells from the bottom is not mixing with cooler ground water in the well casing and measure [illegible] to the surface.

[illegible] flowing artesian wells with [illegible] temperature sonde into the well casing were logged. Wells equipped with pumps or which would require extensive dismantling of control valves, discharge pipes, etc., were avoided to reduce the risk of damage to personal property or loss of equipment. The "Gossett well", logged through the closed 2-inch diameter pipe, was not allowed to flow while logging. The well at Camp Aqua could not be logged without making radical modifications to the well head to accommodate the manner of logging the temperature sonde. Location of the wells are given in Figure 1.

Examination of the temperature logs enclosed show the following:

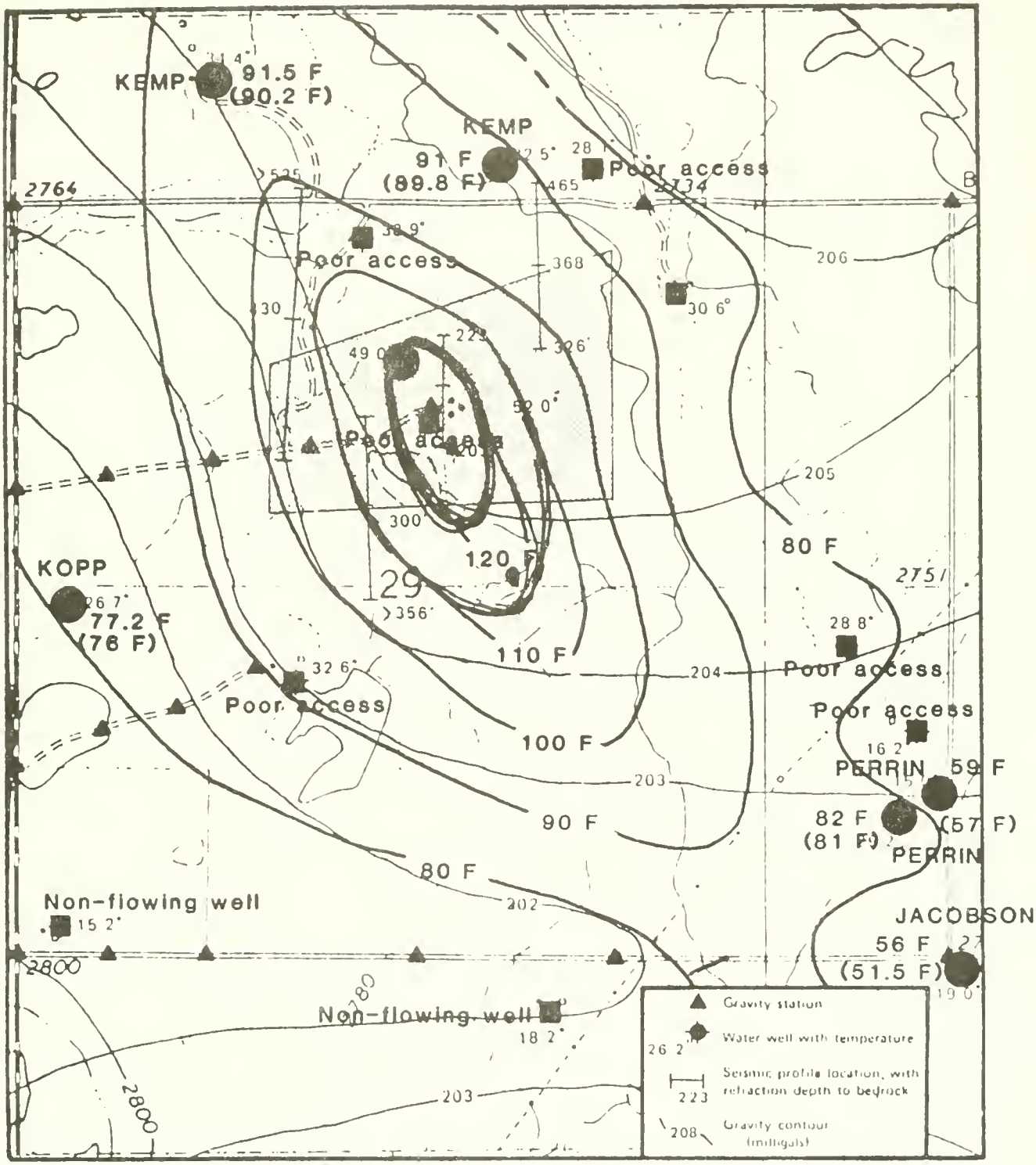
1. Bottom-hole temperature is one to four degrees Fahrenheit greater than discharge temperature measured at the well head.

2. Temperature of the ground water is relatively constant as expected in a flowing well from a few feet above the bottom of the well casing to about 50 feet below ground surface where temperature decreases more rapidly.

3. Bottom-hole temperature is lower than outflow temperatures indicated in the "Donovan Report" suggesting a seasonal variation in temperature of up to about 3.5°F.

The temperature data provided from the Donovan Report and that collected by WEN, INC. personnel were used to construct a temperature contour map. The isotherms exhibit the same northwest-southeast linear trend suggested by chemical data (Donovan, 1981) which parallels the suspected normal fault along the eastern margin of the Little Bitteroot Valley. Unfortunately, data points immediately southeast of Camp Aqua which would serve to refine the isotherms, are lacking.

DCB:bh



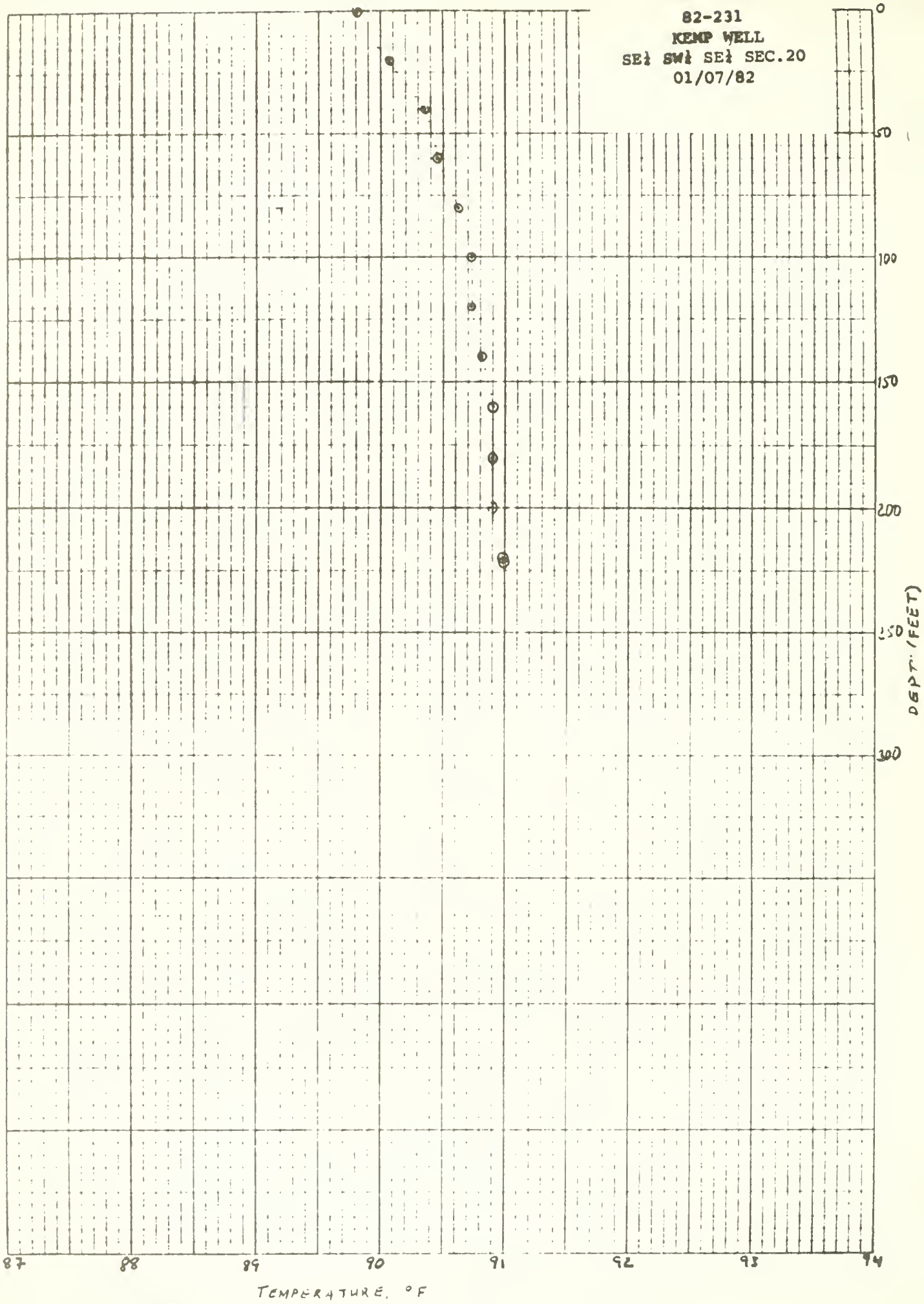
Prepared by WEN INC., January 1982 (ref: Donovan and Sondereger, 1981)

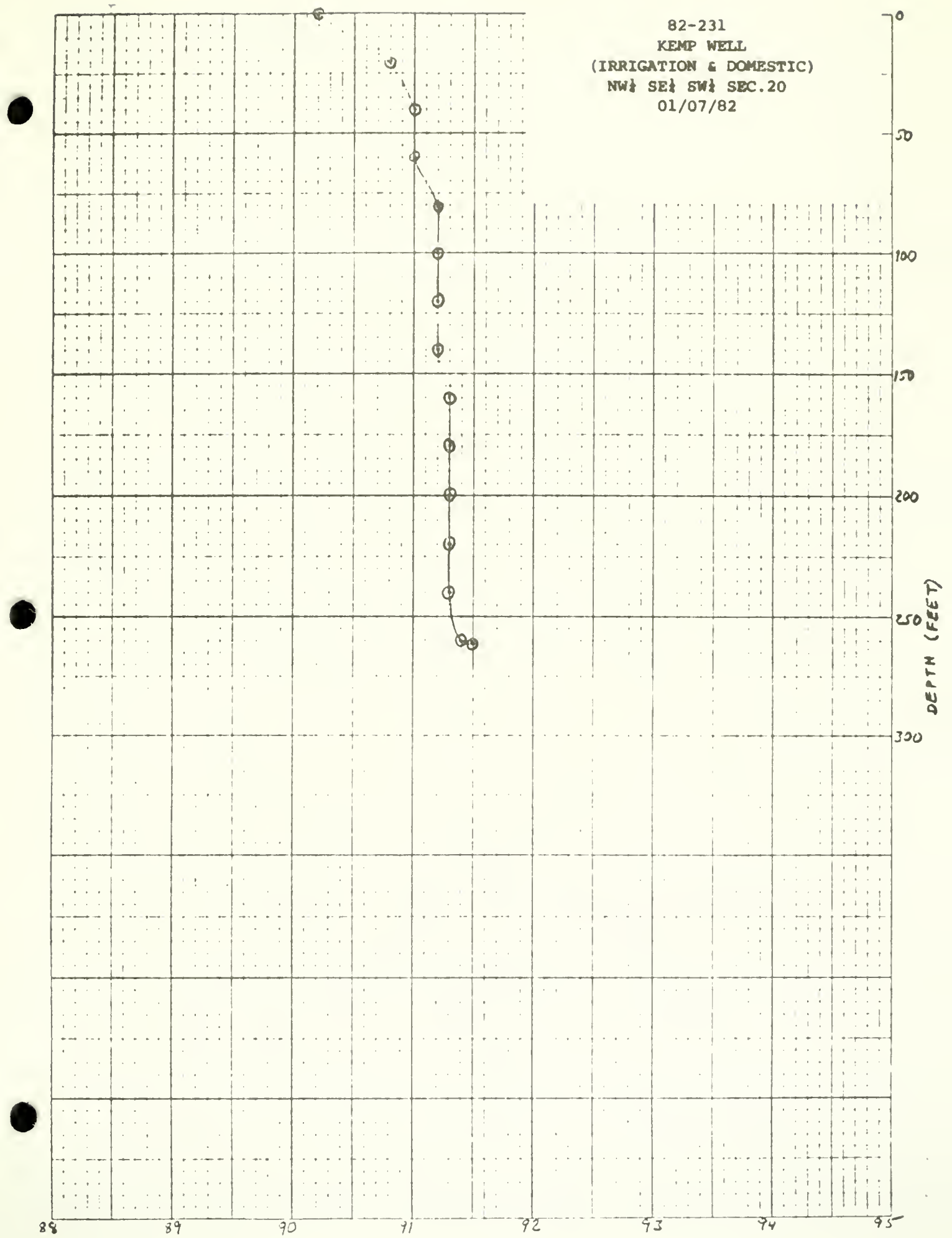
■ - Well which was NOT T-logged

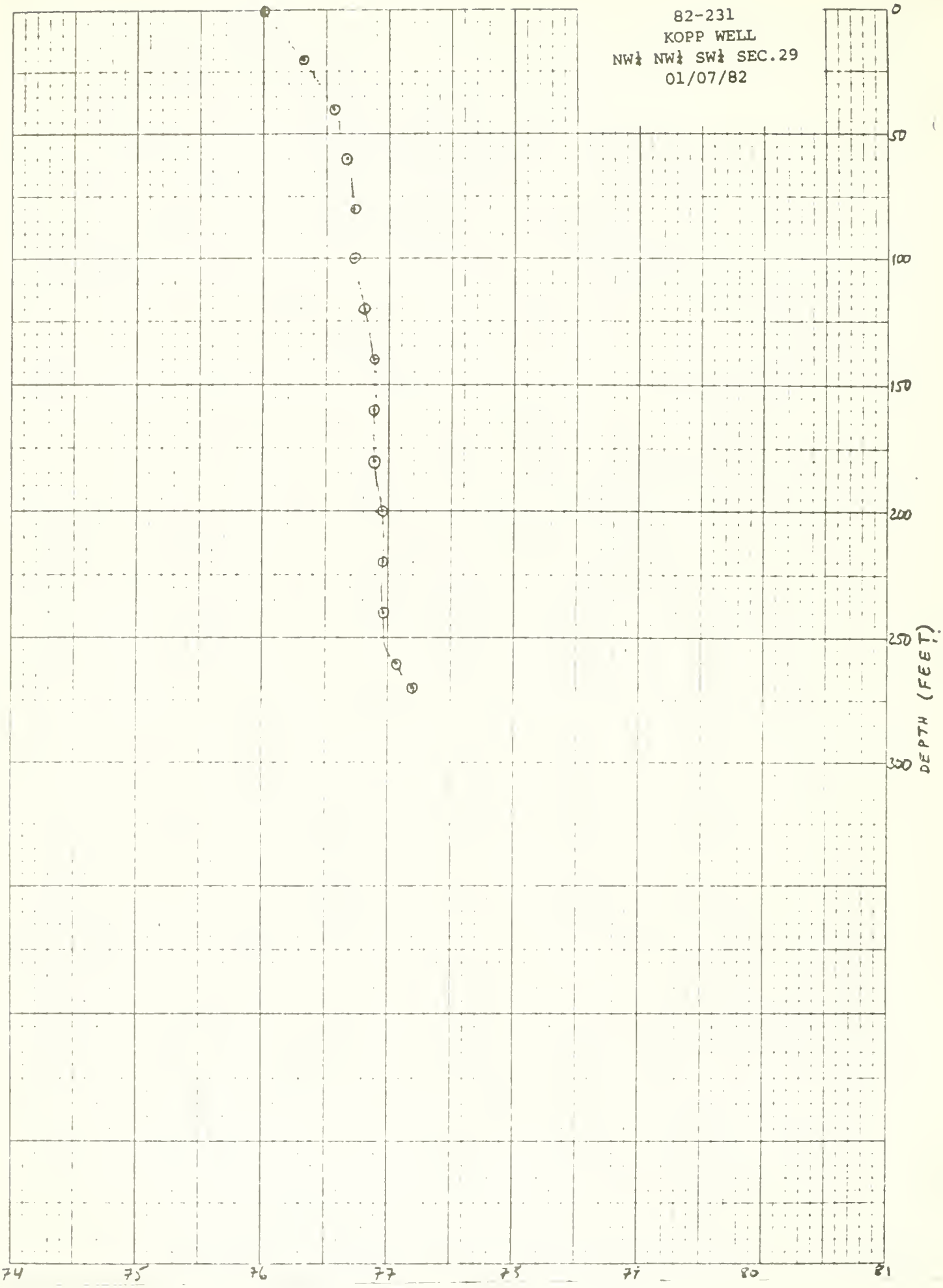
● - Well which was T-logged 01/07/82

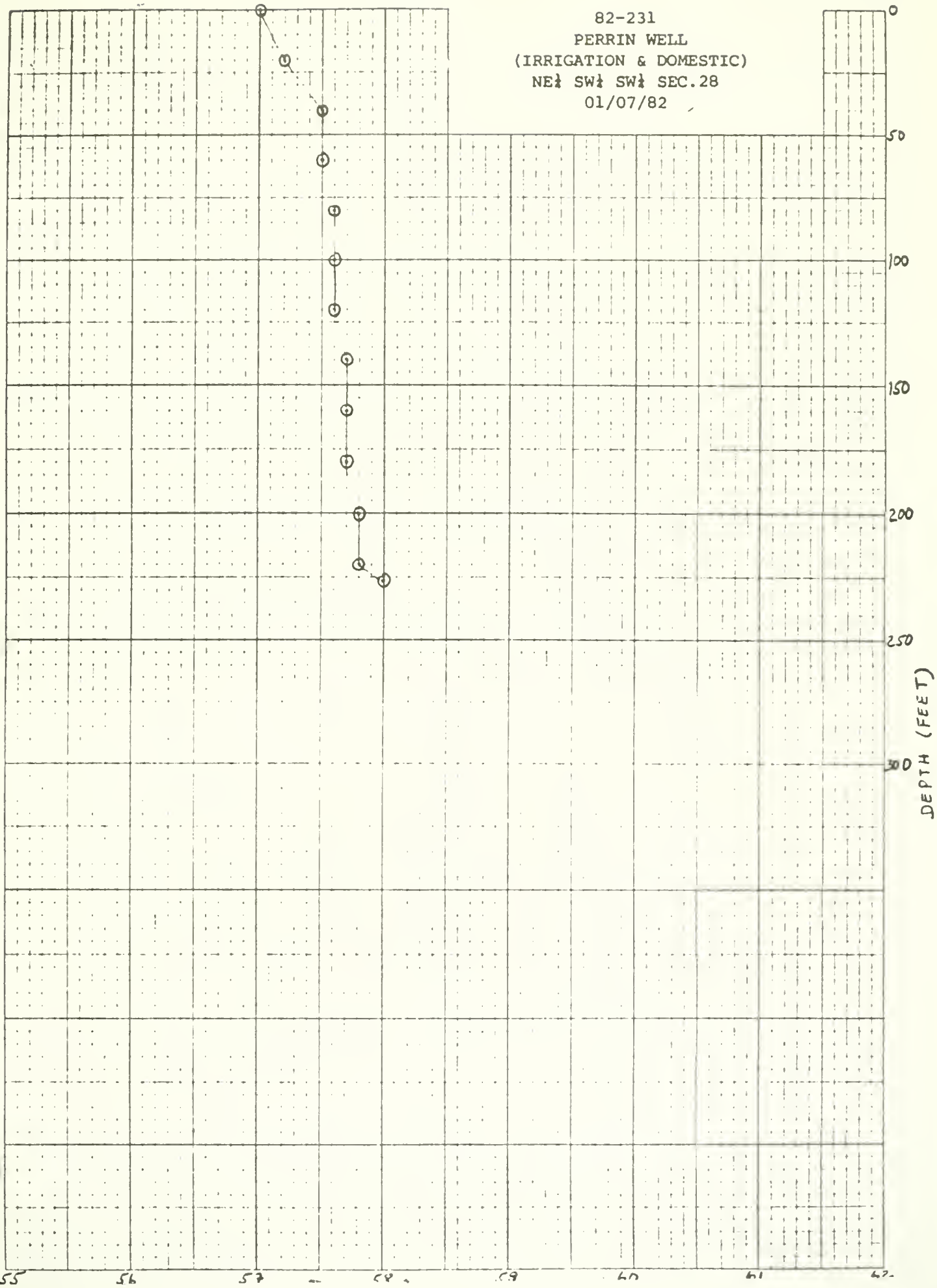
Example: 85 F - Bottom-hole temperature (83 F) - Out-flow temperature

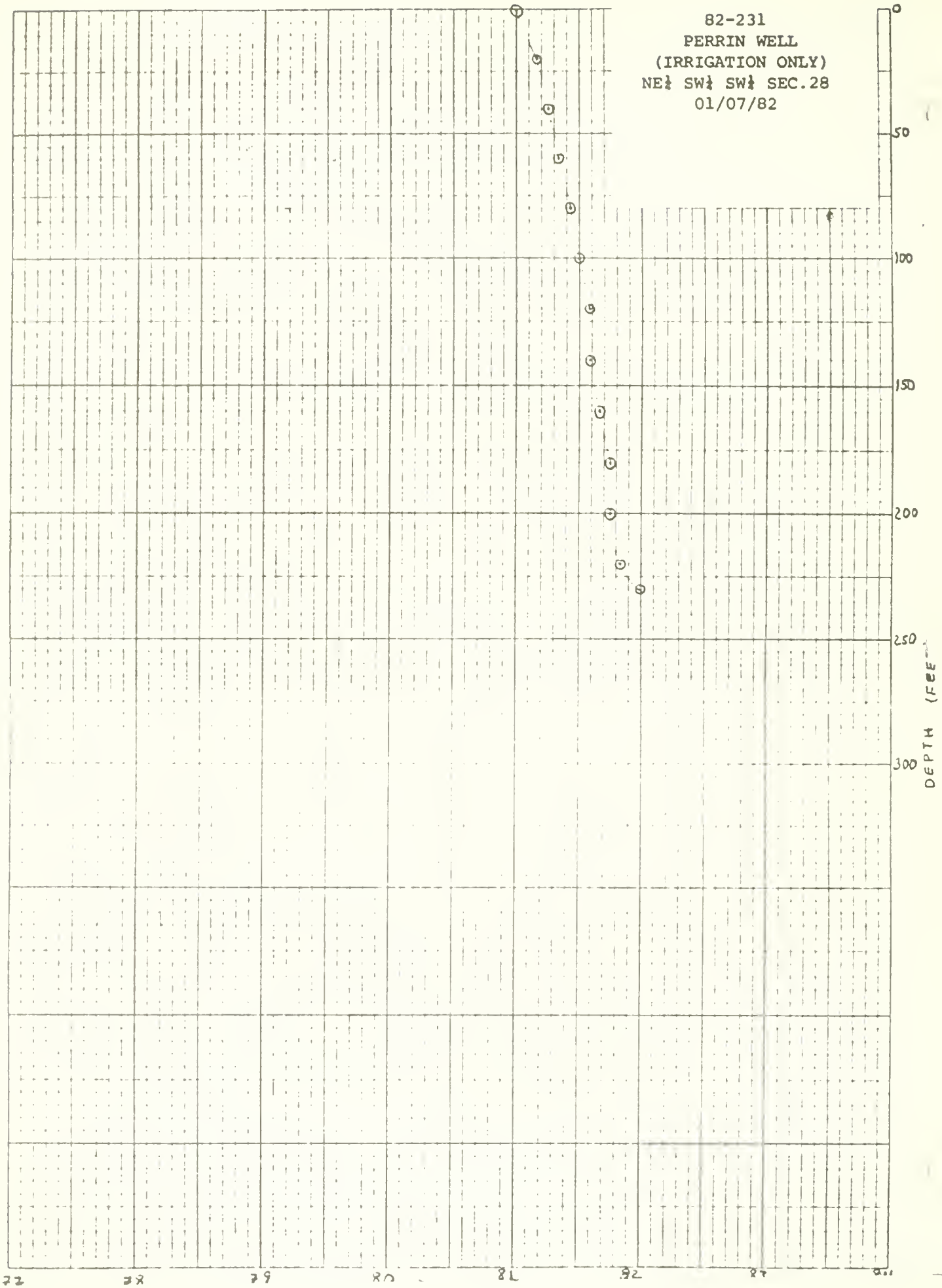
Figure 1. Thermal contours of the artesian aquifer in the vicinity of Camp Aqua

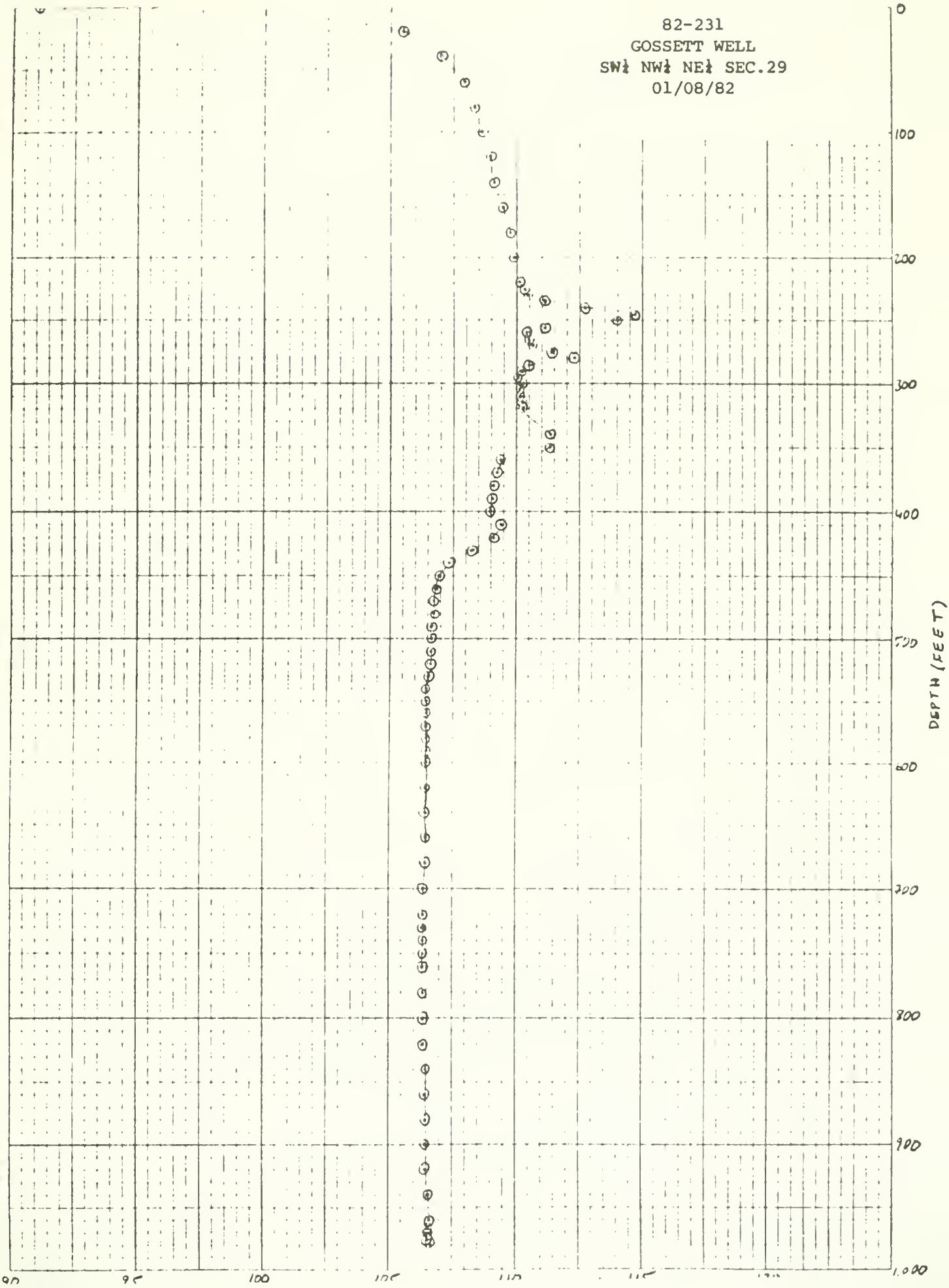

82-231
KEMP WELL
SE¼ SW¼ SE¼ SEC.20
01/07/82
0
50
100
150
200
250
300
DEPTH (FEET)
87
88
89
90
91
92
93
94
TEMPERATURE, °F

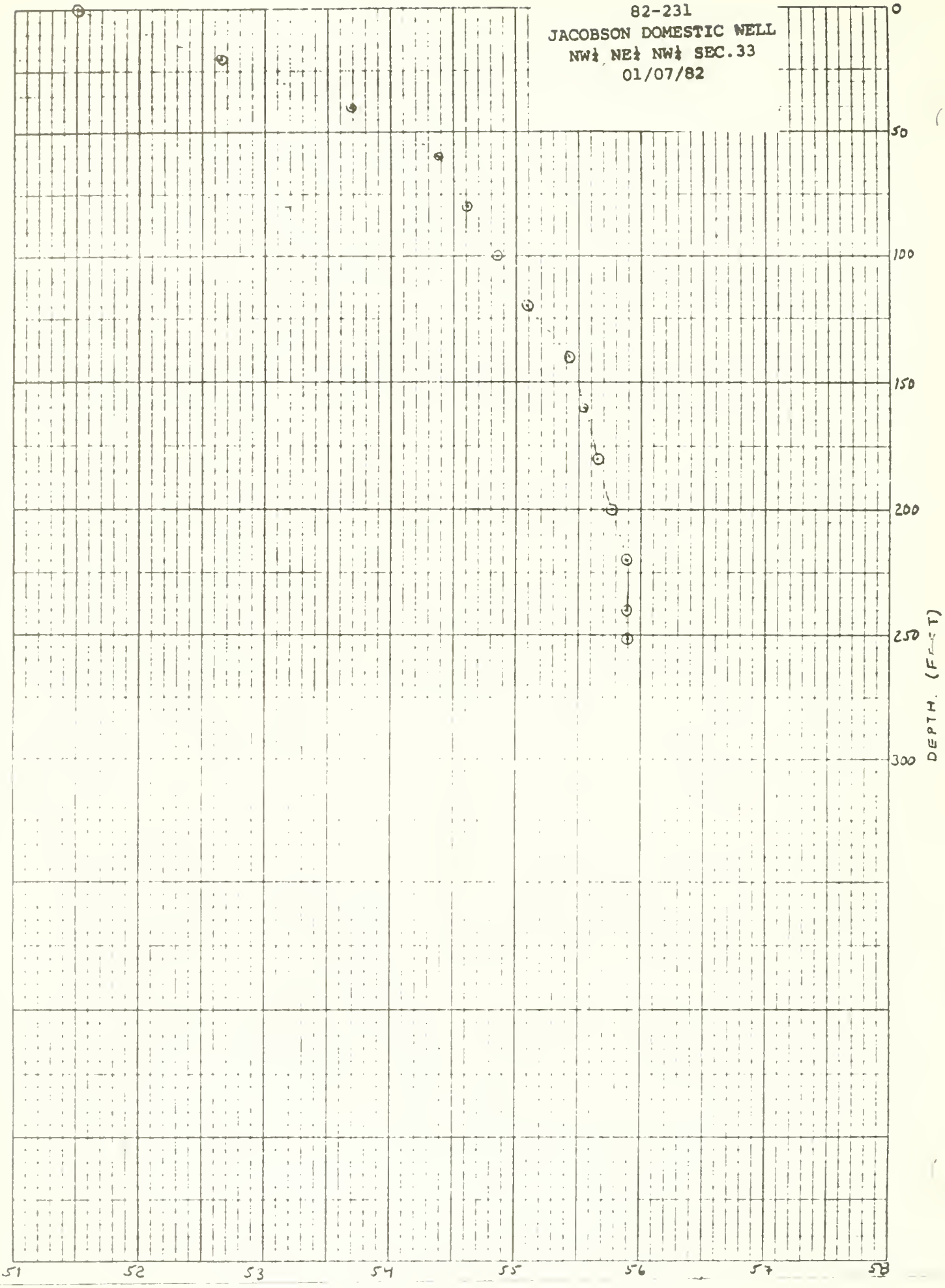

82-231
KEMP WELL
(IRRIGATION & DOMESTIC)
NW¼ SE¼ SW¼ SEC.20
01/07/82
0
50
100
150
200
250
300
DEPTH (FEET)
88
89
90
91
92
93
94
95


82-231
KOPP WELL
NW¼ NW¼ SW¼ SEC.29
01/07/82
0
50
100
150
200
250
300
DEPTH (FEET)
74
75
76
77
78
79
80
81


82-231
PERRIN WELL
(IRRIGATION & DOMESTIC)
NE¼ SW¼ SW¼ SEC.28
01/07/82
0
50
100
150
200
250
300
DEPTH (FEET)
55
56
57
58
59
60
61
62


82-231
PERRIN WELL
(IRRIGATION ONLY)
NE¼ SW¼ SW¼ SEC.28
01/07/82
0
50
100
150
200
250
300
DEPTH (FEET)


82-231
GOSSETT WELL
SW¼ NW¼ NE¼ SEC.29
01/08/82
0
100
200
300
400
500
600
700
800
900
1,000
DEPTH (FEET)
90
95
100
105
110
115


82-231
JACOBSON DOMESTIC WELL
NW¼ NE¼ NW¼ SEC.33
01/07/82
0
50
100
150
200
250
300
DEPTH (FEET)
51
52
53
54
55
56
57
58

JACKOLA ENGINEERING COMPANY

SUMMARY OF THE FIELD INVESTIGATION FOR GEOTHERMAL WATER

Date: 10/22/80 (Observation time: 8:30 a.m. - 5:30 P.M.)

Weather: Sunny, clear in morning and slightly cloudy in the afternoon.
Ambient Temperature = 29° F - 65° F.
Mild wind from N.W. to S.E.

Investigators: Henry Sung and Bill Hallstrom

A. Data Collected

(1) Water Flowrate = 127 Gal/Min. at 3' above ground level.
(No flow change was observed in 8 hours measurement)

(2) Water Pressure = 14.5 PSIG at Well Head
10.0 PSIG at Tank Influent
(These values were estimated by the Montana Bureau of Mines & Geology)

(3) pH = 8.36
(No change was observed in 8 hours measurement)

(4) Odor: There was a mild rotten egg smell for 8 hours of investigating time. This particular odor indicates the presence of H_2S Gas.

(5) Water Sampling: Six 50 ml water samples (grab sample) were collected and shipped to laboratory in same day for analysis of gases dissolved in water.

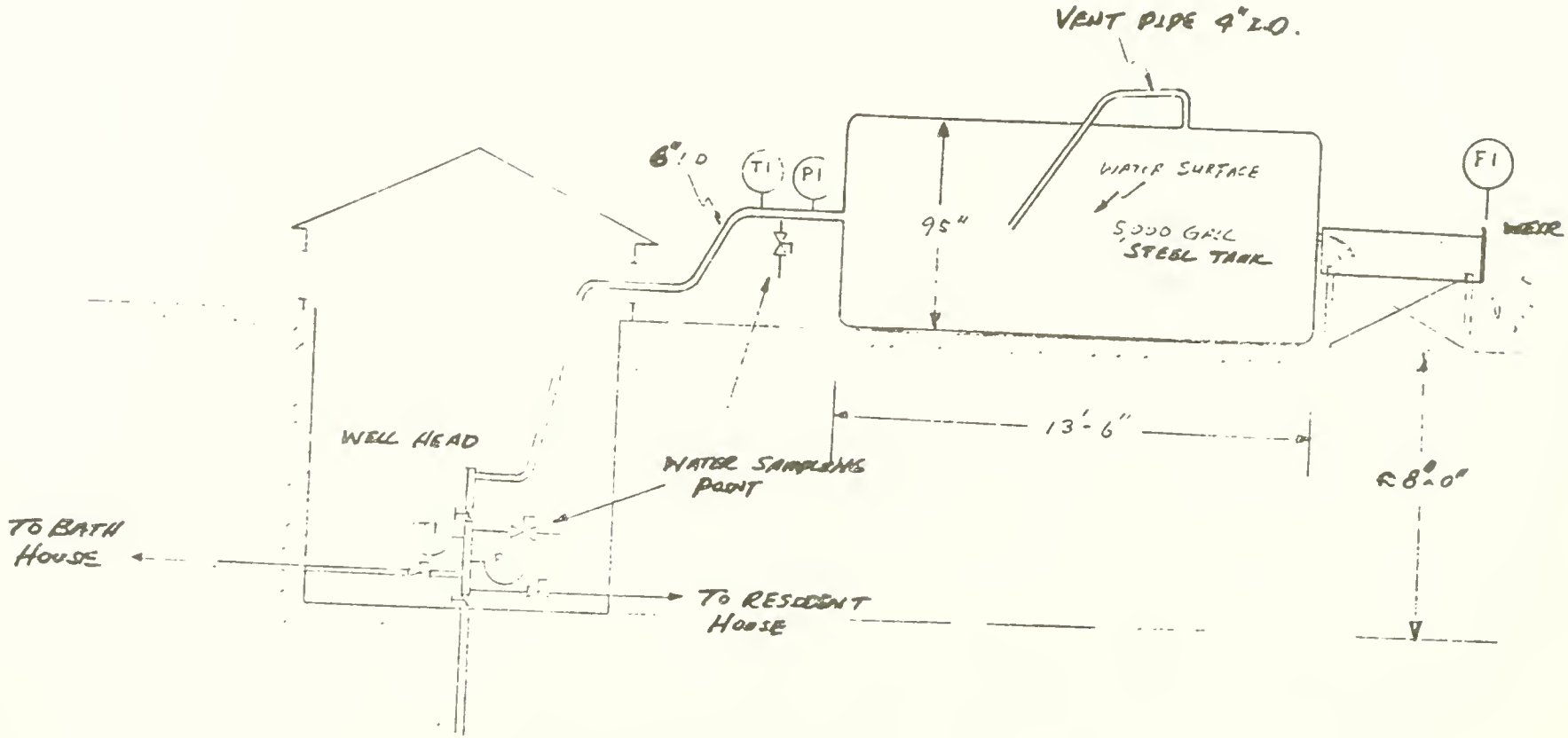
(6) Water Temperature: The water temperature of 125.6^{o} was measured and no temperature change was observed for all day.

B. Comments:

The well has been in existance approaching 70 years. At the time of drilling, area talk suggests that the well was attempted to be plugged with most anything handy at the time. Significant restriction in the well is thought to exist.

THE SITE OF GEOTHERMAL WATER

10/22/80



REPORT
OF
PRELIMINARY GEOTECHNICAL INVESTIGATION

PROPOSED
HOT SPRINGS DEVELOPMENT
Hot Springs, Montana

TO
JACKOLA ENGINEERING
CONSULTING ENGINEERS
Kalispell, Montana

PREPARED
BY
NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
Great Falls, Montana

OCTOBER, 1980

The geologic profile consists of recent alluvium (silts and sands) underlain by lacustrine silty clay. The clay is underlain by gravels which overlie argillite bedrock. At the boring locations, the sand was silty, with occasional silt lenses, loose to medium dense, and wet; depths were 13 and 18.7 feet. Standard penetration resistance (N) values ranged from 9 to 25 blows per foot. The silty clay is a soft to firm lacustrine (lakebed) sediment which reportedly extends to depths in excess of 100 to 200 feet. Available well logs tend to confirm this. The gravel which underlies the clay is of unknown thickness, but is underlain by highly fractured Precambrian argillites. The argillite is also present as the large surface promontory to the northeast of the project. A fault system is likely present at the west edge of this promontory, paralleling the Little Bitterroot River. Hydrothermal waters are percolating up through the rock fractures, into the sand and gravel.

The clays are sensitive and generally normally consolidated, with some evidence of overconsolidation due to desiccation in the upper 10-15 feet.

The moisture content of the subgrade soil increases significantly at 2 to 3 feet below the ground surface. The condition of these soils is such that operation of construction equipment in them will be very difficult. Groundwater was encountered at depths of 5 to 6 feet. Monitoring wells were placed in two of the borings.

Spread footings and mat foundations can be used to support light loads, where settlement can be accommodated. Structural fill will probably be required for these footings. For heavy loads, wood friction piling (allowable load about 20-30 tons) should be used. For this load range, we estimate 30 to 50 foot lengths will be required.

Data regarding the temperature, flow rates, and chemical composition of the geothermal waters from wells in the project area are summarized in Table I. Well locations are shown on the sketch.

Review of these data indicates that the water has:

1) a high sodium content;
2) relatively low hardness and low to moderate alkalinity;
3) low iron and hydrogen sulfide content, but sufficient for a metallic taste and slight rotten egg smell;
4) slight to moderate corrosivity potential by the Ryznar and Langlier indices;
5) the project falls within a zone that is ringed with wells providing relatively warm ($\pm 25^{\circ}C$) water, as illustrated on the sketch; maximum temperature is 51.2° at well No. 32.

Flow rates range from slight to large, with artesian conditions in almost all wells. While there are unconfirmed reports that indicate new wells may influence the discharge rate of existing wells, we understand that your project concept provides for recycling almost all of the water by injecting the cooled water back into the acquifer. Thus, the net effect on the groundwater regime or existing wells should be negligible. Follow-on studies will provide a better understanding of the mechanics of the groundwater regime and the affect of well use on it so that the most effective plan for reinjection can be developed.

Historically, there have been numerous spas, bath houses, and residential heating systems in the Camas and Hot Springs areas, which have used the hot groundwater. Although some are still in operation, most have been abandoned for various reasons.

CONCLUSIONS AND PRELIMINARY RECOMMENDATIONS

1. The surface and near-surface soils can support lightly to moderately loaded spread footings, which would be typical of one-story, wood-frame and masonry construction. For footings 3 to 5 feet wide, with loads of about 2000 pounds per square foot, settlement of up to 1-1/2-inch should be expected. The use of structural fill pads or site fill will reduce settlement and provide a more stable work area.

2. Where heavy loads are involved, a deep foundation system will be necessary. For preliminary design and estimating purposes, timber piling 30 to 50 feet long should support loads of 20 to 30 tons, with settlement of about 1/2 inch.

3. Any underground construction will be difficult, involve special safety considerations, and will probably penetrate groundwater at some locations. Excavation slopes must be flat, or be shored. Access roads and parking areas will require special design features where cuts are involved, and good drainage in all cases.

4. As the project scope and layout are developed, and specific loads and conformation of structures are known, additional field investigations and laboratory analysis should be undertaken, so that appropriate specific recommendations can be developed. These will provide opportunities for substantial economies in design and construction.

5. There is a potential for geothermal development in the area, provided sound engineering design and management is incorporated into the development. Items requiring further study, which are immediately evident, include corrosion, influence of new wells on the system regime, proper well installation to prevent runaways, and disposal of cooled water. Others may appear as the project is studied in more detail.

Jackola Engineering
Kalispell, MT

We wish to thank Mr. Joseph J. Donovan of the Montana Bureau of Mines and Geology for his cooperation and assistance in providing data and information about the area.

It has been a pleasure assisting you with this study. If you have any questions, or if we may be of further service, please contact us.

Respectfully submitted,

Leland J. Walker, P.E.

Robert W. Gillespie, P.E.

LJW/RWG/mb
Enclosures
In quadruplicate

Northern Testing Laboratories
CONSULTING ENGINEERS

Field and Laboratory Investigations
Engineering Analysis and Recommendations
Consultation

Great Falls Billings Montana — Boise Pocatello Idaho — Gillette Wyoming

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Great Falls, Montana 59401
(406) 453-1641

14 October 1980

Jackola Engineering
P. O. Box 1134
Kalispell, MT 59901

SUBJECT: Preliminary Geotechnical Investigation
Hot Springs Development

Gentlemen:

In accordance with our agreement dated 28 March 1980, we have conducted a preliminary geotechnical investigation and geologic reconnaissance at the above-referenced project. The purpose of this investigation was to ascertain subsurface and geologic conditions as they would apply to development of a tract near Hot Springs, Montana, for a large capacity grain processing and alcohol manufacturing facility.

INVESTIGATIONS

Our work consisted of drilling nine test borings, researching available literature, discussions with Montana Bureau of Mines and Geology personnel, and analysis of the acquired data. Four of the borings were 25 feet deep, and five, 50 feet deep. They were located as shown on the enclosed sketch 80-152-1.

Samples obtained from the borings were inspected and classified in the laboratory according to the procedures of the Unified Soils Classification System. Confirming tests such as particle size analysis and Atterberg limits were performed on selected samples. Consolidation and unconfined compression tests were made of representative samples. The results of all field and laboratory tests are summarized on Table II and the Plates. This information, along with the field data, was used to prepare the final test borings logs in the Appendix.

FINDINGS

The site is irrigated (flood-type) pasture land on the property known as Camp Aqua, about four miles northeast of Hot Springs. It is bounded on the west by the Sanders County-Lake County line, on the south by the half section line (Section 29, R23W, T22N), and on the east by the Little Bitterroot River. Topography is that of a broad, shallow river valley, with drainage toward the east.

EXPLORATION AND LABORATORY TESTING

Exploration

Field exploration is performed using truck- or skid-mounted rotary drilling machine equipped with either augers, tricone rock bits, or coring apparatus. Standard penetration testing and undisturbed sampling can be performed through our hollow-stem auger, which serves as casing. When drilling in large, dense gravel, rock fragments, or bedrock, special casing is usually required to maintain an open hole. The soils are continuously logged by an engineer or geologist and classified by visual examination in accordance with the Unified Soils Classification System.

Samples of soils are taken at frequent intervals in the boring excavation. Disturbed samples are normally taken by the standard penetration test. This test is made by driving a 2-inch O.D. split-spoon sampler 18 inches into the soil by striking it with a 140-pound hammer dropping 30 inches. The total number of blows required to advance the sampler the second and third 6-inch increments is the standard penetration resistance. Occasionally, a cone penetrometer will be driven continuously from the ground surface to locate soft zones or to simulate the driving of piling into subsurface soils. The cone is 1-13/16 inches in diameter and is driven with the same hammer and dropping distance as the standard penetrometer. Undisturbed samples are obtained from layers of soil that are critical to the analysis. Samples of representative soils are obtained by pushing, or possibly driving, a thin-walled steel sampler into the soil layer. The soil is retained in brass rings of 2.00 to 2.50 inches in diameter and 1.00 inches in height. Normally, the central 6-inch portion of the sample is retained in close-fitting, plastic, waterproof containers which are in turn placed in cushioned boxes for shipment to the laboratory. Occasionally, thin-walled shelby tubes are used to sample sensitive soils that are easily disturbed.

Under certain conditions and with certain project requirements, in-place vane shear, percolation, resistivity and/or California bearing ratio tests may be performed in accordance with standard procedures.

Laboratory Classification & Testing

The field classification is verified in the laboratory, where all of the samples are classified by an experienced person other than the one who made the field classification. The classification process in the laboratory normally includes estimation of the percents of gravel or rock fragments, sand, silt, and clay fractions, and the liquid and plastic limits. The natural moisture content of all of the fine-grained soil and bedrock samples is determined.

Based on the classification tests, one or more of each representative type of soil encountered is selected for more detailed analysis. The data from the field and the laboratory investigations is used to prepare the final test boring logs (shown on the Drawing).

Moisture - Natural Density

Moisture content and in-place density tests are used to determine local variations in soil consistency. This information can also provide a correlation between soils found at this site and other sites in the general area. The dry unit weight and moisture content of selected undisturbed samples, or of in-place soil layers, and the moisture content of all cohesive or fine-grained samples are determined.

Consolidation

The apparatus used for the consolidation test is designed to receive one of the 1-inch-high rings of soil as it comes from the field. Loads are applied to the test specimen in several increments, and the resulting deformations are recorded at selected time intervals. Porous stones are placed in contact with the top and bottom of the specimen to permit the ready addition or release of water.

Samples are tested at their field moisture content and at increased moisture content where the soils may become saturated during the life of the structure.

SUMMARY OF WATER PROPERTIES

HOT SPRINGS DEVELOPMENT
TABLE 1

Well No.	Shut-in Pressure psi gage	Temperature °C	Flow gpm	Static Water, Feet Below Ground Surface	Sodium mg/l	Iron mg/l	Bicarbonate mg/l	Hydrogen Sulfide mg/l	Ryznar Stability Index	Langlier Saturation Index	pH
12		19.8									
13		17.2		45.2							
14		15.7									
15		13.8									
16		13.6		13.0							
17		26.4	2.2	Flowing	139	0.11	331.84		8.3	-0.1	8.18
18		15.8	10.0								
19	±12.0	16.4		Flowing							
20				"							
21		25.6		"							
22	14.4	18.1		"							
23		34.4		"	150	0.02	326.0	0.1	8.3	0.2	8.63
24		32.0		Runaway Well							
25		28.1		Flowing							
27		28.8		"	147	0.26	348.0	0.2	8.99	-0.55	7.89
28		16.2	7200	"							
29		15.0		"							
30		29.0		"							
31		32.4	100	"	154.4	0.13	354	0.5	8.76	-0.24	8.41
32	12.2	51.2		Flowing Around Casing	150.0	0.05	352.3		8.8	-0.02	8.30
33		36.7		Flowing	144.0	0.65	314.0	0.7	8.42	-0.02	8.38
34		32.3	60-100	"							
35		19.0									
36		15.2									
38		18.2									
39		15.0									
40		12.9									
41		18.2									
42		13.9									

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

SUMMARY OF FIELD AND LABORATORY TEST RESULTS
HOT SPRINGS DEVELOPMENT
TABLE II

Job No. 80-152

Boring Number	Depth in Feet	Classification	Penetration Test Blows Per Foot	Moisture Content Percent	Atterberg Limits: Liquid Limit,%	Atterberg Limits: Plastic Limit,%	Atterberg Limits: Plasticity Index,%	Gradation Percent Retained: Gravel	Gradation Percent Retained: Sand	Gradation Percent Retained: Silt	Gradation Percent Retained: Cl
DH 1	3.5 - 5.0	SILT	20	26							
	8.5 - 10.0	SAND, Silty	11	28				0	1	-99-	
	14.0 - 15.0	CLAY, Silty	25	25				0	75	-25-	
	18.5 - 20.0	CLAY, Silty	10	37							
	25.5 - 28.0	CLAY, Silty	9	40	46	24	22	0	0	11	8
	28.5 - 30.0	CLAY, Silty	14	40							
	33.5 - 35.0	CLAY, Silty	14	42							
	38.5 - 40.0	CLAY, Silty	14	47							
	43.5 - 45.0	CLAY, Silty	9	44							
	48.5 - 50.0	CLAY, Silty	7	42							
DH 2	3.5 - 5.0	SAND, Silty	9	25							
	8.5 - 10.0	SAND, Silty	17	26							
	13.5 - 15.0	CLAY, Silty	14	32							
	18.5 - 20.0	CLAY, Silty	10	36							
	23.5 - 25.0	CLAY, Silty	13	43							
DH 3	3.5 - 5.0	SAND, Silty	9	23							
	8.5 - 10.0	SAND, Silty	11	26							
	13.5 - 15.0	SAND, Silty	27	22							
	15.0 - 16.5	CLAY, Silty	13	32							
	18.5 - 20.0	CLAY, Silty	6	37							
	23.5 - 25.0	CLAY, Silty	9	38							
DH 4	3.5 - 5.0	CLAY, Silty	2	22							
	8.5 - 10.0	CLAY, Silty	2	22							
	20.5 - 22.0	CLAY, Silty	--	--							
	23.5 - 25.0	CLAY, Silty	23	27							
	28.5 - 30.5	CLAY, Silty	--	--							
	30.5 - 32.0	CLAY, Silty	7	47							
	33.5 - 35.0	CLAY, Silty	7	33							
	38.5 - 40.0	CLAY, Silty	8	36							
	43.5 - 45.0	CLAY, Silty	4	45							

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

SUMMARY OF FIELD AND LABORATORY TEST RESULTS
HOT SPRINGS DEVELOPMENT
TABLE II

Job No. 80-152

Boring Number	Depth in Feet	Classification	Penetration Test Blows Per Foot	Moisture Content Percent	Atterberg Limits: Liquid Limit,%	Atterberg Limits: Plastic Limit,%	Atterberg Limits: Plasticity Index,%	Gradation Percent Retained: Gravel	Sand	Silt	Cl
DH 5	0.2 - 0.8	CLAY, Silty	11	6							
	3.5 - 5.0	SAND, Silty	12	8							
	8.5 - 10.0	CLAY, Silty	34	27							
		In-place Dry Density = 96 pcf; see Plate No. 1 for additional test data.									
	13.5 - 15.0	CLAY, Silty	15	31							
	18.5 - 20.5	CLAY, Silty	--	--							
	20.5 - 22.0	CLAY, Silty	17	34							
	23.5 - 25.0	CLAY, Silty	12	39							
DH 6	0.3 - 1.5	CLAY, Silty	21	6							
	3.5 - 5.0	CLAY, Silty	27	21							
	8.5 - 10.5	CLAY, Silty	--	--							
	10.5 - 12.0	CLAY, Silty	16	28							
	13.5 - 15.0	CLAY, Silty	10	29							
	18.5 - 20.0	CLAY, Silty	--	--							
	20.0 - 22.5	CLAY, Silty	8	36							
	23.5 - 25.0	CLAY, Silty	7	42							
	28.5 - 30.0	CLAY, Silty	8	47							
	33.5 - 35.0	CLAY, Silty	4	43							
	43.5 - 45.0	CLAY, Silty	6	54							
	45.0 - 46.5	CLAY, Silty	9	40							
	48.5 - 50.0	CLAY, Silty	5	35							
DH 7	3.5 - 5.0	SILT, Clayey	10	1							
	8.5 - 10.0	SAND, Silty	12	2							
	13.5 - 15.0	CLAY, Silty	31	13							
	18.5 - 20.0	CLAY, Silty	26	28							
	23.5 - 25.0	CLAY, Silty	10	35							
	28.5 - 30.0	CLAY, Silty	9	38							
	33.5 - 35.5	CLAY, Silty	-	--							
	35.5 - 37.0	CLAY, Silty	9	28							
	38.5 - 40.0	CLAY, Silty	9	43							
	43.5 - 45.0	CLAY, Silty	8	36							
	48.5 - 50.0	CLAY, Silty	8	4							

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS

SUMMARY OF FIELD AND LABORATORY TEST RESULTS
HOT SPRINGS DEVELOPMENT
TABLE II

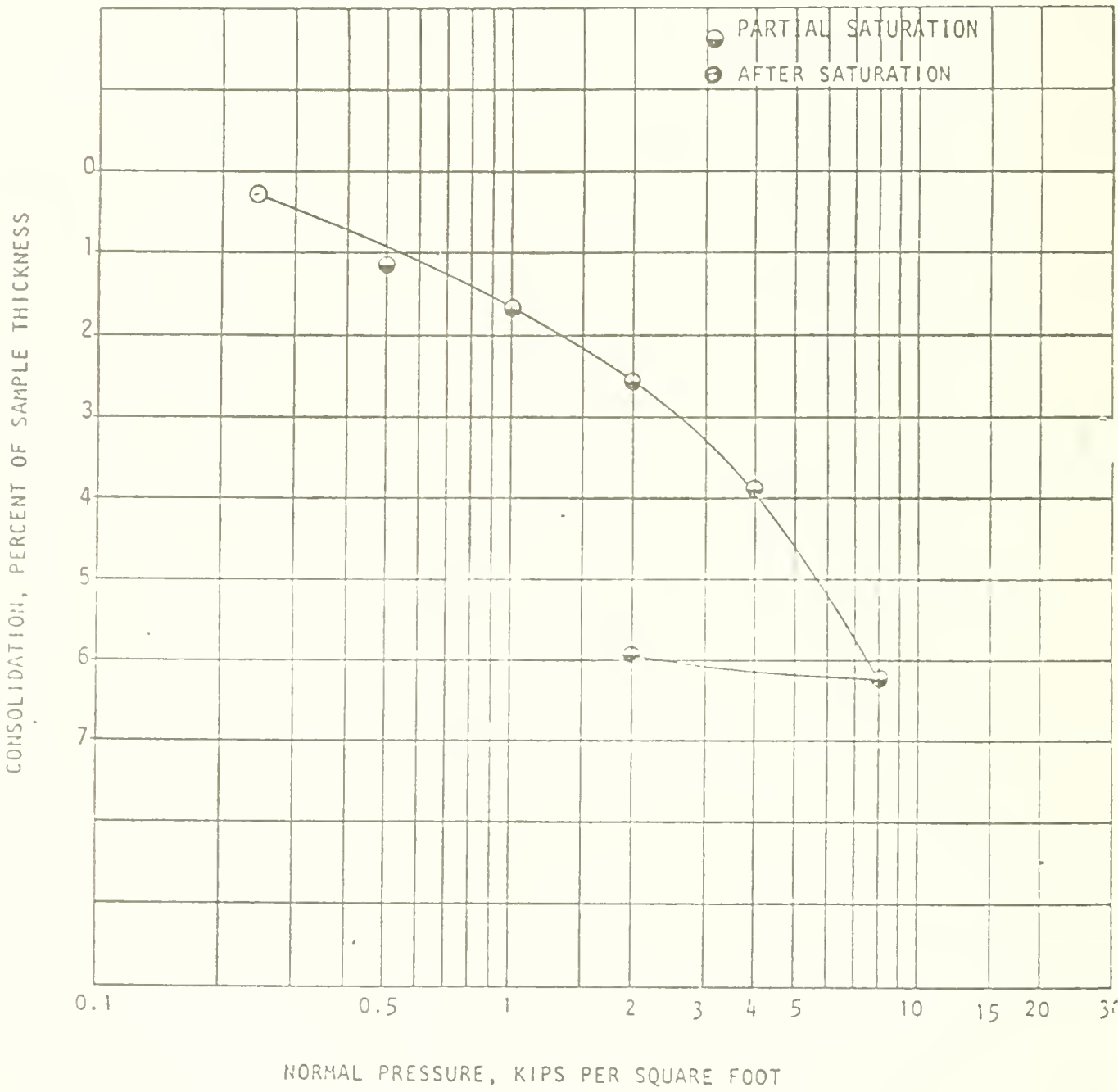
Job No. 80-152

Boring Number	Depth in Feet	Classification	Penetration Test Blows Per Foot	Moisture Content Percent	Atterberg Limits: Liquid Limit,%	Atterberg Limits: Plastic Limit,%	Atterberg Limits: Plasticity Index,%	Gradation Percent Retained: Gravel	Sand	Silt	Cl
DH 8	0.6 - 1.5	CLAY, Silty	14	9							
	3.5 - 5.0	CLAY, Silty	2	21							
	8.5 - 10.5	CLAY, Silty	--	--							
	10.5 - 12.0	CLAY, Silty	1	29							
	13.5 - 15.0	CLAY, Silty	3	26							
	18.5 - 19.5	CLAY, Silty	3	25							
	23.5 - 25.0	CLAY, Silty	4	26							
	28.5 - 30.0	CLAY, Silty	20	27							
	33.5 - 35.0	CLAY, Silty	13	36							
	38.5 - 40.0	CLAY, Silty	6	47							
	43.5 - 45.0	CLAY, Silty	--	--							
	45.5 - 47.0	CLAY, Silty	19	31							
	48.5 - 50.0	CLAY, Silty	--	32							
DH 9	3.5 - 5.0	CLAY, Silty	4	25							
	8.5 - 10.0	CLAY, Silty	9	31							
		In-place Dry Density = 93 pcf; see Plate Nos. 2 & 3 for additional test data.									
	13.5 - 15.5	CLAY, Silty	--	--							
	15.5 - 17.0	CLAY, Silty	18	34							
	18.5 - 20.0	CLAY, Silty	13	39							
	23.5 - 25.0	CLAY, Silty	8	29							

CONSOLIDATION TEST

DRILL HOLE 5
DEPTH 8.5' - 10.5'
SAMPLE NO. 162528

MOIST UNIT WEIGHT : 121 pcf
DRY UNIT WEIGHT : 96 pcf
INITIAL MOISTURE CONTENT: 27 %
FINAL MOISTURE CONTENT : 22 %
CLASSIFICATION : CLAY, Silty

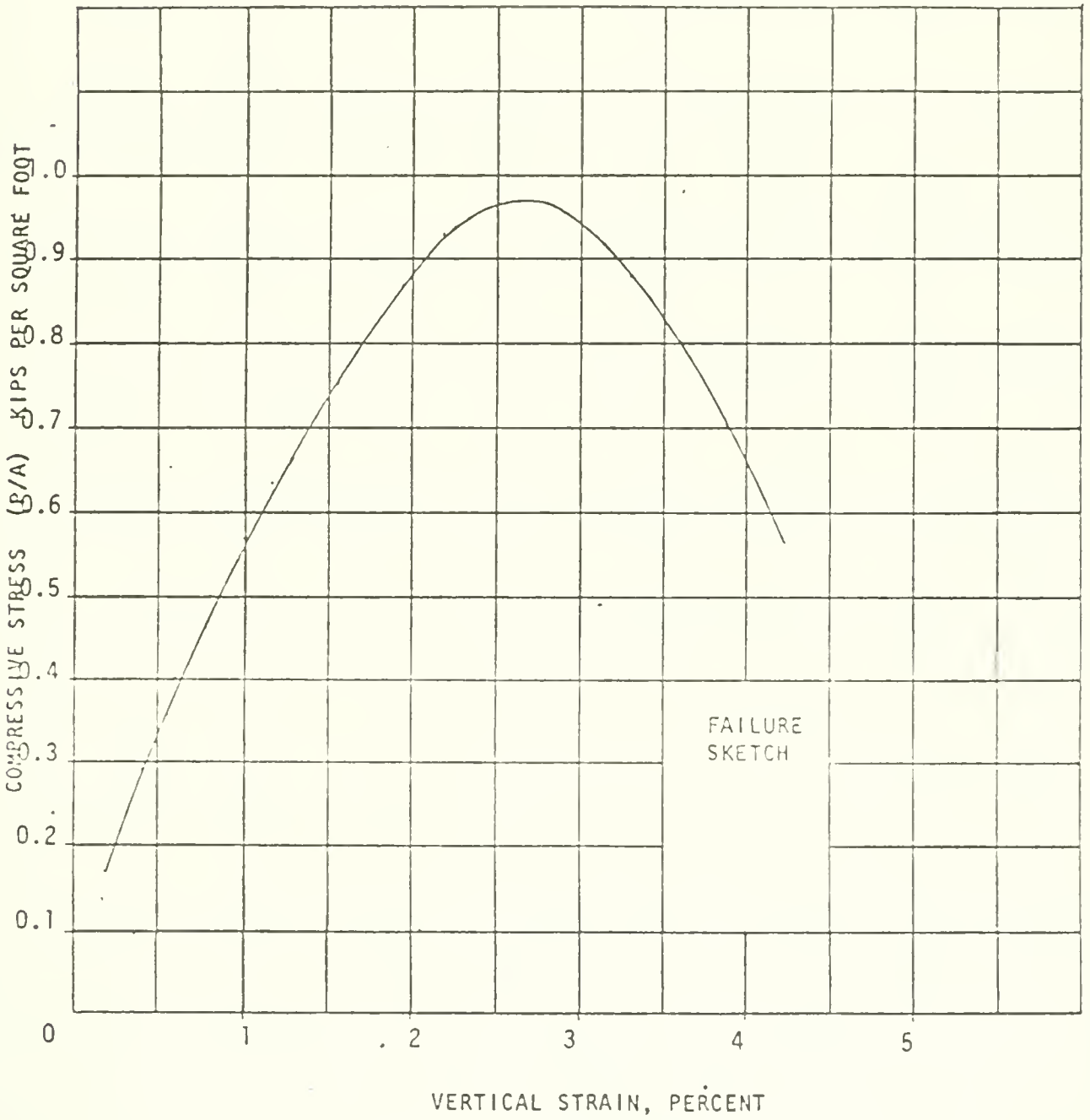


HOT SPRINGS DEVELOPMENT HOT SPRINGS, MONTANA	NORTHERN TESTING LABORATORIES, INC. CONSULTING GEOTECHNICAL ENGINEERS GREAT FALLS, MONTANA
JACKOLA ENGINEERING KALISPELL, MONTANA	

UNCONFINED COMPRESSION TEST

DRILL HOLE 9
DEPTH 13.5' - 14.5'
SAMPLE NO. 162541

MOIST UNIT WEIGHT: 122 pcf
DRY UNIT WEIGHT : 93 pcf
MOISTURE CONTENT : 31 %
CLASSIFICATION : CLAY, Silty
HEIGHT TO DIAMETER RATIO: 2:1
RATE OF STRAIN: 0.5% per minute



HOT SPRINGS DEVELOPMENT
HOT SPRINGS, MONTANA

JACKOLA ENGINEERING
KALISPELL, MONTANA

NORTHERN TESTING LABORATORIES, INC.
CONSULTING GEOTECHNICAL ENGINEERS
GREAT FALLS, MONTANA

LOGS OF EXPLORATIONS

EXPLANATION OF ABBREVIATIONS

SSS (SPT)	-	Standard penetration resistance test -- results recorded as the number of blows of a 140-pound hammer falling 30 inches required to drive a 2-inch O.D. split sample spoon the second and third 6-inch increments of an 18-inch distance.
LSS	-	Modified penetration test -- results recorded as the number of blows of a 140-pound hammer falling 30 inches required to drive a 2.5-inch O.D. split sample spoon the second and third 6-inch increments of an 18-inch distance.
CPT	-	Cone penetration test -- results recorded as the number of blows of a 140-pound hammer falling 30 inches required to drive a 1-13/16-inch-diameter cone one foot.
SRS	-	Split barrel ring sample 2-inches I.D. for taking undisturbed samples.
LRS	-	Split barrel ring sampler 2.5-inches I.D. for taking undisturbed samples.
STS	-	Shelby tube sample for taking undisturbed samples (2" to 3-5/16" I.D.).
Sack (SK) or Bag	-	Sample of disturbed soil placed in canvas sack or plastic bag.
GWL	-	Groundwater level on day of completion of field investigations.
FD	-	In-place dry density.
RQD	-	Rock quality designation (RQD) for the bedrock samples are determined for each core run by summing the length of all sound, hard pieces of core over 4 inches in length, and dividing this number by the total length of the core run. This value, along with the core recovery percentage, is recorded on the drill logs.

LOG OF EXPLORATION HOLE

PROJECT: HOT SPRINGS DEVELOPMENT

JOB NO.: 80-152

DRILL TYPE: SOIL Mobile B-50

ROCK

DRILLED BY: D. Gray

LOGGED BY: J. Ferris

REMARKS:

HOLE NO. DH 1

SHEET 1 OF 2

LOCATION 165' N of centerline of access road & 925' E of gravel road

ELEVATION: TOP OF HOLE 2800 (±)

GROUNDWATER --

DATE: HOLE STARTED 4-29-80

HOLE COMPLETED 4-29-80

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0.3		Topsoil, organic matter.										
			SPT	20	26				0	1	-99-	
		SAND, Silty; loose to medium dense, wet, occasionally grading to silt, with silt lenses, trace of carbon detritus.										
10			SPT	11	28				0	75	-25-	
			SPT	25	25							
18.7			SPT	10	37							
		CLAY, Silty; soft to firm, wet, varved, trace of carbon detritus.	SPT	9	40		46	22	0	0	11	89
30			SPT	14	40							
			SPT	14	42							
			SPT	14	47							

continued...

HOLE NO. DH 1

SHEET 2 OF 2

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S P T (N) (BLOWS FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L L %	P I %	GRAVEL %	SAND %	SILT %	CLAY %
40		CLAY, Silty; soft to firm, wet, varved, trace of carbon detritus.	SPT	9	44							
			SPT	7	42							
50.0		BOTTOM OF HOLE										

LOG OF EXPLORATION HOLE

PROJECT: HOT SPRINGS DEVELOPMENT

JOB NO.: 80-152

DRILL TYPE: SOIL Mobile B-50

ROCK

DRILLED BY: D. Gray

LOGGED BY: J. Ferris

REMARKS:

HOLE NO. DH 2

SHEET 1 OF 1

LOCATION 185' S Of access road & 660' E of gravel road

ELEVATION: TOP OF HOLE 2600 (±)

GROUNDWATER --

DATE: HOLE STARTED 4-30-80

HOLE COMPLETED 4-30-80

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0		Topsoil, organic matter.										
0.3		SAND, Silty; loose to medium dense, wet, occasionally grading to silt, with silt lenses, trace of carbon detritus.	SPT	9	25							
			SPT	17	26							
13.0		CLAY, Silty; firm, wet, varved, trace of carbon detritus.	SPT	14	32							
			SPT	10	36							
25.0			SPT	13	43							
		BOTTOM OF HOLE										

LOG OF EXPLORATION HOLE

PROJECT: HOT SPRINGS DEVELOPMENT

JOB NO.: 80-152

DRILL TYPE: SOIL Mobile B-50, 9" Hollow Auger

ROCK

DRILLED BY: G. Skaer

LOGGED BY: J. Ferris

REMARKS:

HOLE NO. DH 3

SHEET 1 OF 1

LOCATION See Drawing No. 80-152-1

ELEVATION: TOP OF HOLE 2777.7

GROUNDWATER N/A

DATE: HOLE STARTED 8/4/80

HOLE COMPLETED 8/4/80

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0		Topsoil, organic material.										
0.1		SAND, Silty; dense to medium dense, moist to wet.	SSS	9	23							
			SSS	11	26							
15.0			LSS	27	22							
			SSS	13	32							
		CLAY, Silty; firm to stiff, moist to very wet.	SSS	6	37							
			SSS	9	38							
25.0		BOTTOM OF HOLE										

LOG OF EXPLORATION HOLE

PROJECT: HOT SPRINGS DEVELOPMENT

JOB NO.: 80-152

DRILL TYPE: SOIL Mobile B-50, 9" Hollow Auger
ROCK

DRILLED BY: G. Skaer

LOGGED BY: J. Ferris

REMARKS: *50' of perforated PVC pipe installed.

HOLE NO. DH 4*

SHEET 1 OF 2

LOCATION See Drawing No. 80-152-1

ELEVATION: TOP OF HOLE 2746.5
GROUNDWATER 2741.5

DATE: HOLE STARTED 8/5/80
HOLE COMPLETED 8/5/80

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0												
0.2		Topsoil, organic material.										
		CLAY, Silty; very soft, wet to saturated.										
5.0		GWL (8/5/80)	SSS	2	22							
			SSS	2	22							
11.0												
		SAND, Silty; medium dense, saturated.										
22.0												
			SSS	23	27							
		CLAY, Silty; stiff to soft, very wet.										
			SSS	7	47							
			SSS	7	33							
			SSS	8	36							

continued...

JOB NO. 00 192 HOLE NO. BH 4 SHEET 2 OF 2

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	SPT (N) (BLOWS FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	LL %	PI %	GRAVEL %	SAND %	SILT %	CLA
40		CLAY, Silty; stiff to soft, very wet.	SSS	4	45							
			SSS	3	43							
50.0		BOTTOM OF HOLE										

LOG OF EXPLORATION HOLE

PROJECT: HOT SPRINGS DEVELOPMENT

JOB NO.: 80-152

DRILL TYPE: SOIL Mobile B-50, 9" Hollow Auger

ROCK

DRILLED BY: G. Skaer

LOGGED BY: J. Ferris

REMARKS:

HOLE NO. DH 5

SHEET 1 OF 1

LOCATION See Drawing No. 80-152-1

ELEVATION: TOP OF HOLE 2781.6

GROUNDWATER N/A

DATE: HOLE STARTED 8/7/80

HOLE COMPLETED 8/7/80

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0		Topsoil, organic material.										
0.6		CLAY, Silty; firm, moist.	LSS	11	6							
0.8		SAND, Silty; medium dense, moist.	LSS	12	8							
8.5		CLAY, Silty; stiff, very wet.	SSS	34	27	96						
			SSS	15	31							
			SSS	17	34							
15.0			SSS	12	39							
		BOTTOM OF HOLE										

NTL 150

LOG OF EXPLORATION HOLE

PROJECT: HOT SPRINGS DEVELOPMENT

JOB NO.: 80-152

DRILL TYPE: SOIL Mobile B-50, 9" Hollow Auger
ROCK

DRILLED BY: G. Skaer

LOGGED BY: J. Ferris

REMARKS:

HOLE NO. DH 6

SHEET 1 OF 2

LOCATION See Drawing No. 80-152-

ELEVATION: TOP OF HOLE 2753.0
GROUNDWATER 2748.0

DATE: HOLE STARTED 8/5/80
HOLE COMPLETED 8/5/80

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DENSITY DRY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0												
0.3		Topsoil, organic material.	LSS	21	6							
5.0		GWL (8/5/80)	SSS	27	21							
			SSS	16	28							
		CLAY, Silty; stiff to soft, moist to saturated, silt lenses.	SSS	10	29							
20			SSS	8	36							
			SSS	7	42							
			SSS	8	47							
40			SSS	4	43							

continued...

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S P T (N) (BLOWS FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L L %	P I %	GRAVEL %	SAND %	SILT %	CLAY %
40		CLAY, Silty; stiff to soft, moist to saturated, silt lenses.	SSS	6	54							
			SSS	9	40							
			SSS	5	35							
50.0		BOTTOM OF HOLE										

LOG OF EXPLORATION HOLE

PROJECT: HOT SPRINGS DEVELOPMENT

JOB NO.: 80-152

DRILL TYPE: SOIL Mobile B-50, 9" Hollow Auger

ROCK

DRILLED BY: G. Skaer

LOGGED BY: J. Ferris

REMARKS:

HOLE NO. DH 7

SHEET 1 OF 2

LOCATION See Drawing No. 80-152-1

ELEVATION: TOP OF HOLE 2765.9

GROUNDWATER N/A

DATE: HOLE STARTED 8/5/80

HOLE COMPLETED 8/5/80

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0												
0.2		Topsoil, organic material.										
		SILT, Clayey; stiff, dry.	SSS	10	1							
7.0												
		SAND, Silty; medium dense, dry	SSS	12	2							
10.5												
			SSS	31	13							
		CLAY, Silty; stiff to medium stiff, moist to very wet.	SSS	26	28							
20												
			SSS	10	35							
			SSS	9	38							
			SSS	9	28							
40			SSS	9	43							

continued...

NTL 15C

JOB NO. 80-152 HOLE NO. DH 7 SHEET 2 OF 2

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S P T (N) (BLOWS FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L L %	P I %	GRAVEL %	SAND %	SILT %	CLAY %
40		CLAY, Silty; stiff to medium stiff, moist to very wet.	SSS	8	36							
			SSS	8	43							
50.0		BOTTOM OF HOLE										

NTL 150 A

LOG OF EXPLORATION HOLE

PROJECT: HOT SPRINGS DEVELOPMENT

JOB NO.: 80-152

DRILL TYPE: SOIL Mobile B-50, 9" Hollow Auger

ROCK

DRILLED BY: G. Skaer

LOGGED BY: J. Ferris

REMARKS:

HOLE NO. DH 8

SHEET 1 OF 2

LOCATION See Drawing No. 80-152

ELEVATION: TOP OF HOLE 2737.1

GROUNDWATER 2731.3

DATE: HOLE STARTED 8/7/80

HOLE COMPLETED 8/7/80

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0												
0.6		Topsoil, organic material.	SSS	14	9							
			SSS	2	21							
5.8		GWL (8/7/80)										
			SSS	1	29							
		CLAY, Silty; stiff to 3', then very soft to 25', then stiff, dry to saturated, some sand lenses.	SSS	3	26							
20			SSS	3	25							
			SSS	4	26							
			SSS	20	27							
			SSS	13	36							
40			SSS	6	47							

continued...

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S P T (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DRY DENSITY (pcf)	L L %	P I %	GRAVEL %	SAND %	SILT %	CLAY %
40		CLAY, Silty; stiff to 3', then very soft to 25', then stiff, dry to saturated, some sand lenses.	SSS	19	31							
			SSS	--	32							
50.0		BOTTOM OF HOLE										

NTL 150 A

LOG OF EXPLORATION HOLE

PROJECT: HOT SPRINGS DEVELOPMENT

JOB NO.: 80-152

DRILL TYPE: SOIL Mobile B-50, 9" Hollow Auger

ROCK

DRILLED BY: G. Skaer

LOGGED BY: J. Ferris

REMARKS: *25' of perforated PVC pipe installed.

HOLE NO. DH 9*

SHEET 1 OF 1

LOCATION See Drawing No. 80-152-1

ELEVATION: TOP OF HOLE 2734.1

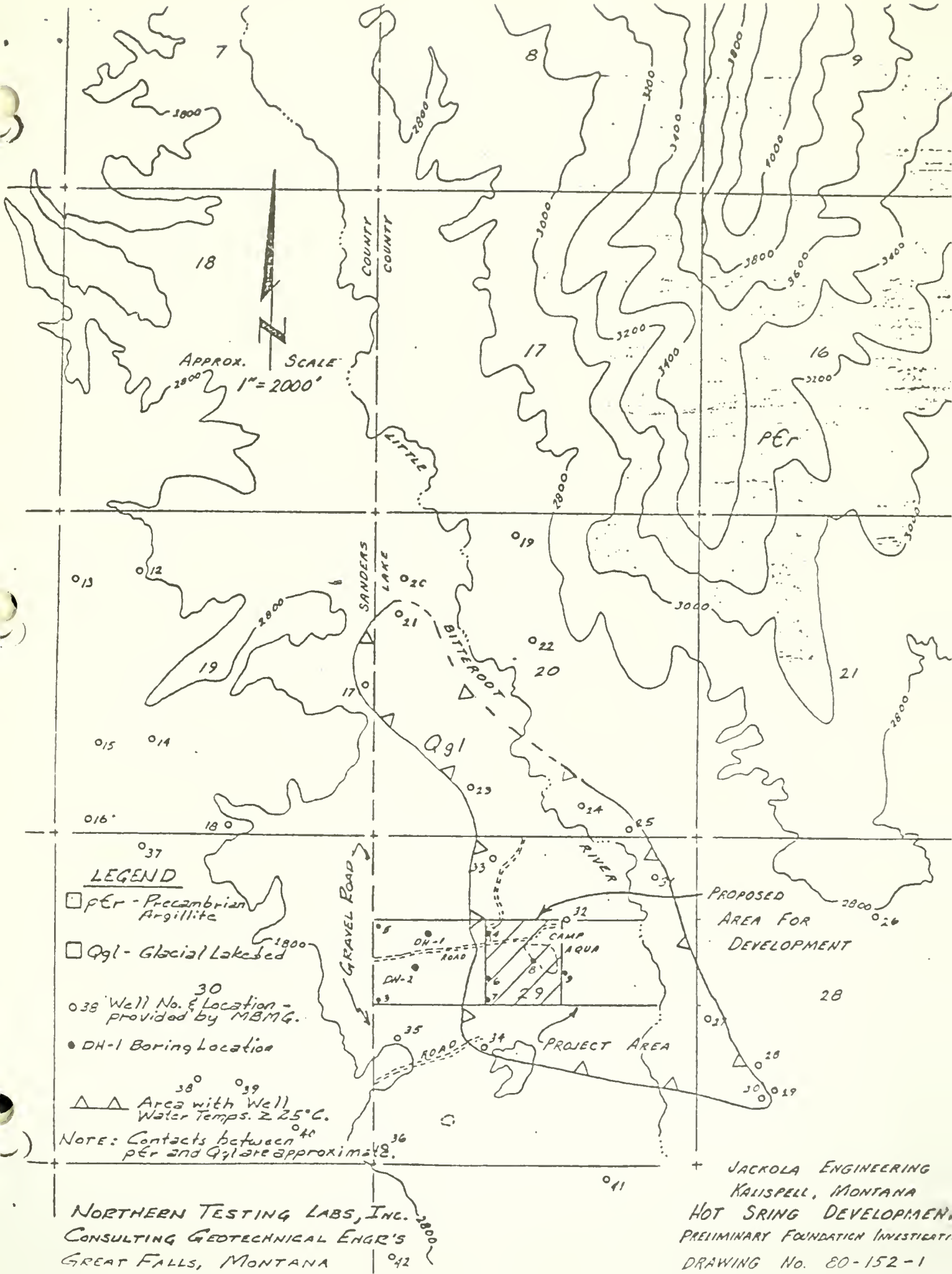
GROUNDWATER N/A

DATE: HOLE STARTED 8/7/80

HOLE COMPLETED 8/7/80

DEPTH (Feet)	LEGEND	CLASSIFICATION AND DESCRIPTION	SAMPLE SYMBOL	S.P.T. (N) (BLOWS/FT.)	MOISTURE CONTENT (%)	IN-PLACE DENSITY DRY (pcf)	L.L. %	P.I. %	GRAVEL %	SAND %	SILT %	CLAY %
0		Topsoil, organic material.										
0.2												
			SSS	4	25							
			SSS	9	31	93						
		CLAY, Silty; soft to stiff, moist to very wet, some sand lenses.										
			SSS	18	34							
			SSS	13	39							
			SSS	8	29							
25.0		BOTTOM OF HOLE										

NTL 150



NORTHERN TESTING LABS, INC.
CONSULTING GEOTECHNICAL ENGR'S
GREAT FALLS, MONTANA

JACKOLA ENGINEERING
KALISPELL, MONTANA
HOT SPRING DEVELOPMENT
PRELIMINARY FOUNDATION INVESTIGATI
DRAWING No. 80-152-1

SECTION 7

AMBIENT AIR SAMPLING

551-811

AMBIENT AIR SAMPLING

An air monitoring station was established by Jackola Engineering Company on the proposed facility site and sampling has been conducted since July 18, 1980. A General Metals high volume sampling system utilizing fiber glass media is being utilized. Meteorological data is being gathered using Weather Measure Corporation sensors and recorder. Temperature, wind speed and direction, precipitation, and barometric pressure data are being collected. The air sampler is mounted about 5.2 meters (17 feet) above ground elevation of 2753.78' mean sea level. Scaffolding upon which the equipment is mounted is situated in an open area midway and on the site along the north property line. This is generally downwind of the proposed plant facility site located approximatley 800 feet to the southwest. Prevailing wind is from the southwest with 90° shifts to the west and east on a regular and relatively uniform basis.

Security for the sampling equipment is provided by a neighboring property owner who can restrict access and could call a technician in case of equipment malfunction. Neither situation has occurred.

Complete results of the ambient sampling program follow.

TYPICAL ANALYTICAL RESULTS

Preweighed Filters

Filter #	Date	CFM	Press	Gross Wt. (g)	Tare Wt. (g)	Net Wt. (g)	Pb (mg/filter)
99	10/19/80	Start 50 Finish 50	30.05	3.5228	3.2815	0.2413	1.4
98	10/21/80	Start 50 Finish 51	30.02	3.5310	3.4810	0.0500	1.8
97	10/26/80	Start 51 Finish 51	30.03	3.5575	3.4831	0.0744	1.3
95	11/02/80	Start 54 Finish 54	30.20	3.5061	3.4892	0.0169	1.5
94	11/04/80	Start 54 Finish 50	30.40	3.5479	3.3062	0.2417	1.1
93	11/06/80	Start 54 Finish 51	30.04	3.5000	3.4760	0.0240	1.8
92	11/09/80	Start 52 Finish 49	30.06	3.4939	3.4056	0.0883	1.6
91	11/11/80	Start 50 Finish 53	30.20	3.5057	3.4899	0.0158	1.7

AUG. 80

CLIENT ENERGY ENGINEERING

LOCATION CAMP AQUA, HOT SPRINGS

SUBJECT PRECIPITATION

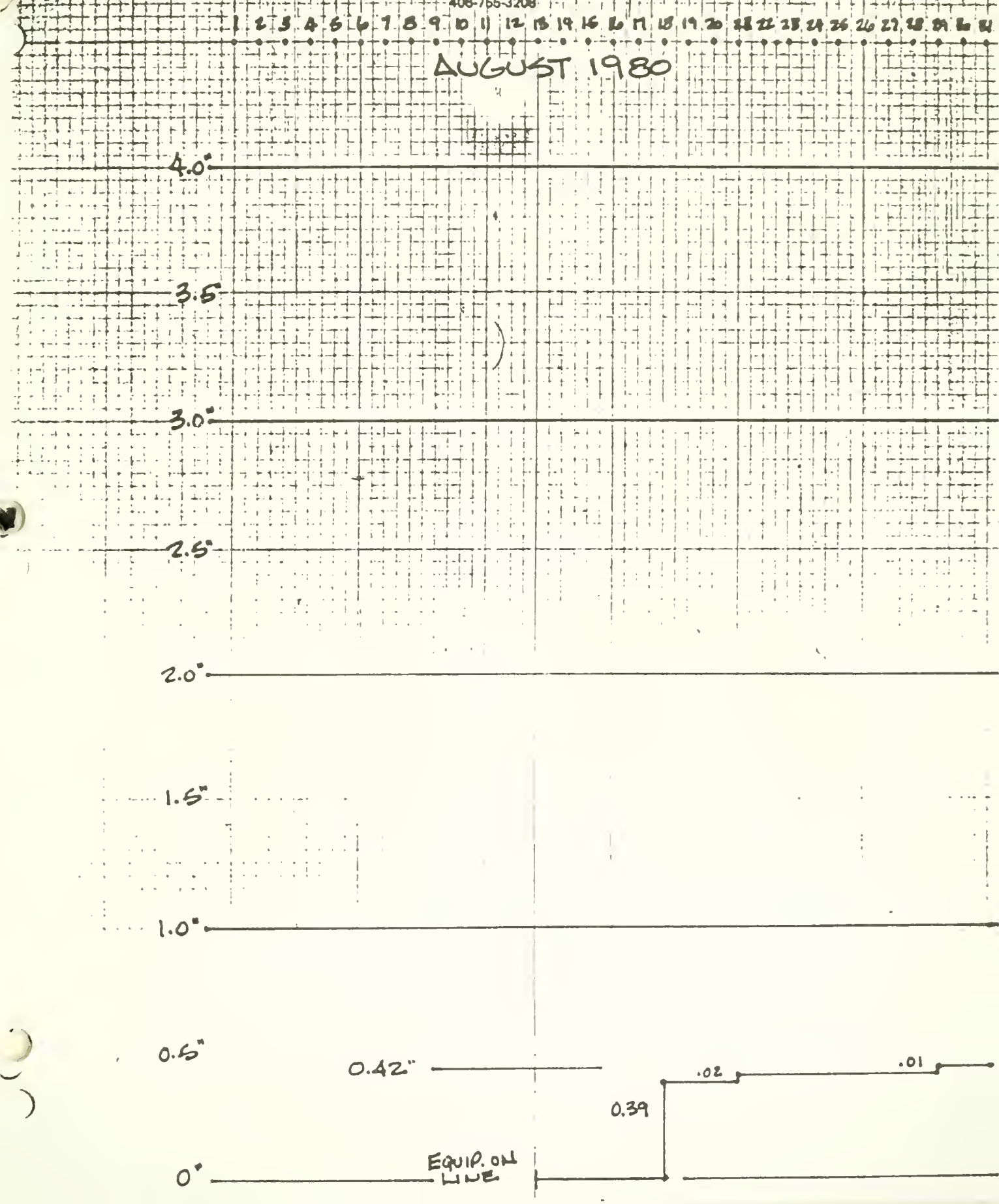
Jackola Engineering Co.

575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

PN _____ SHEET NO. _____

CHECKED BY _____ DATE _____

COMPUTED BY _____ DATE _____



AUG. 1980

CLIENT EVERGY ENGRG.

LOCATION CAMP AQUA, HOT SPRGS.

SUBJECT TEMP.

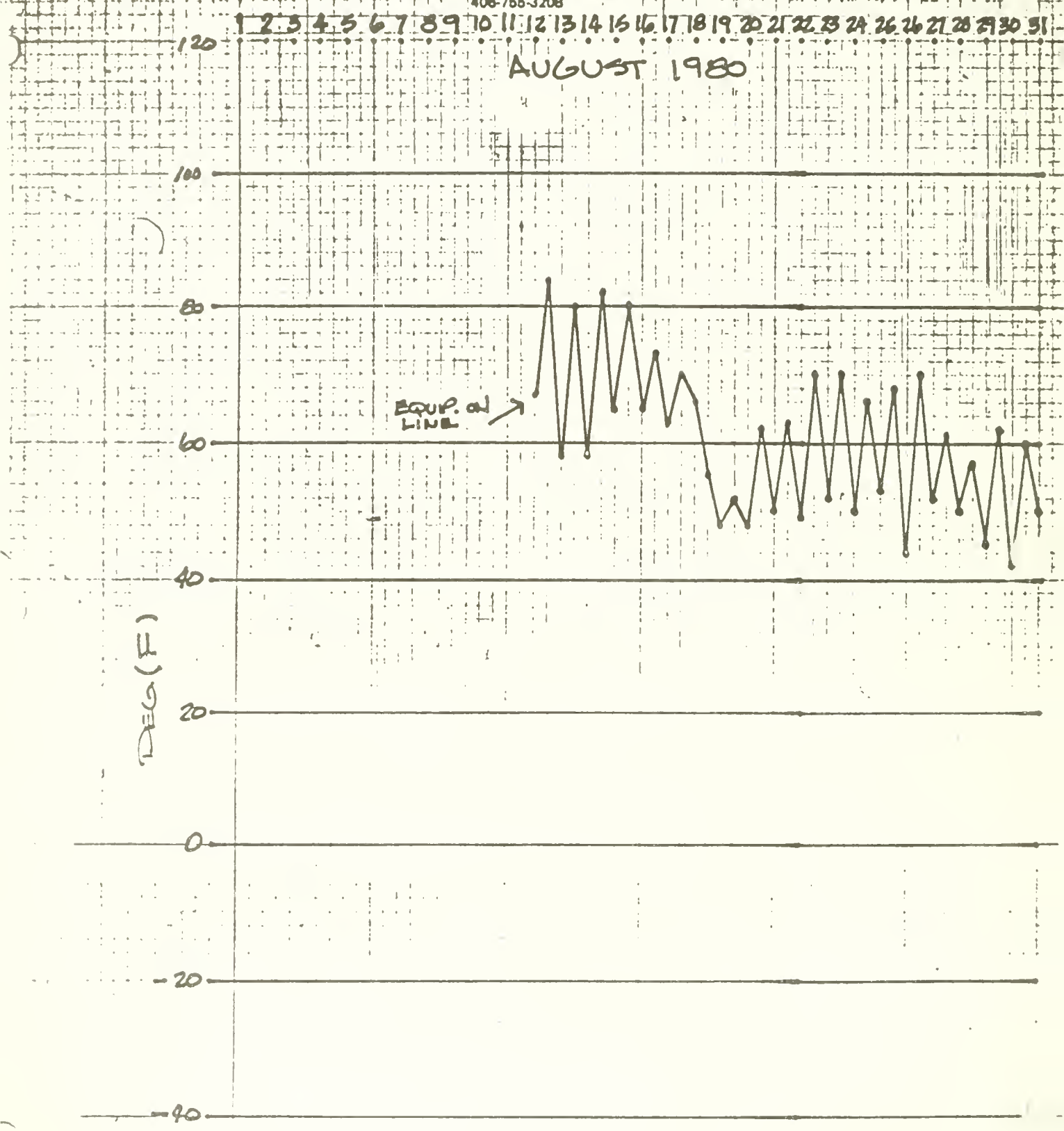
Jackola Engineering Co.

575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

PN _____ SHEET NO. 1

CHECKED BY _____ DATE _____

COMPUTED BY _____ DATE _____



AUG. 80

CLIENT ENERGY ENGINEERING

LOCATION COMP AQUA, HOT SPRINGS

SUBJECT HUMIDITY & PSYCHOMETRIC PROBE

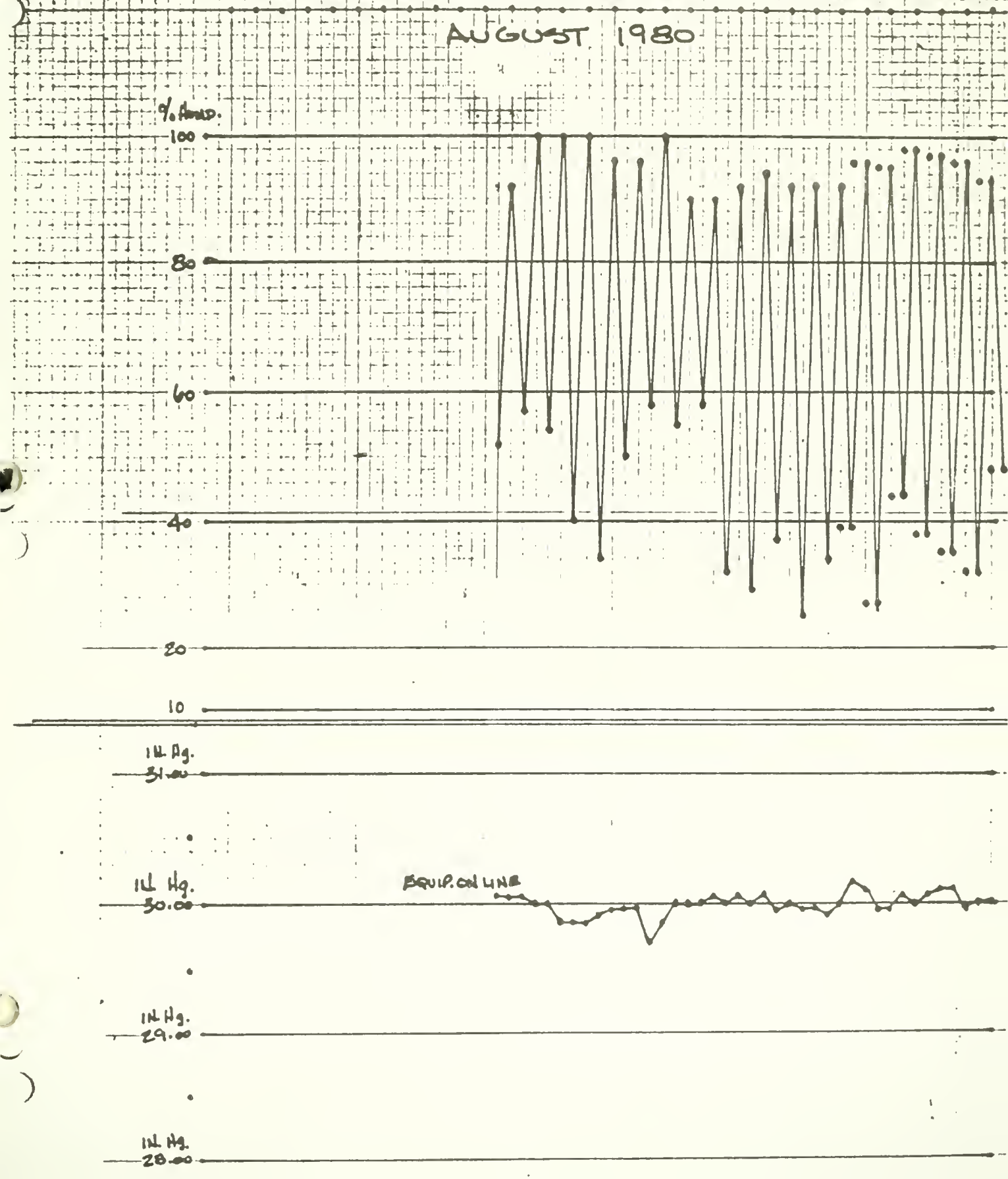
Jackola-Engineering Co.

575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

PN _____ SHEET NO. _____

CHECKED BY _____ DATE _____

COMPUTED BY _____ DATE _____



CLIENT ENERGY ENGINEERING

LOCATION CAMP AQUA, HOT SPRINGS, MT.

SUBJECT WIND VELOCITY

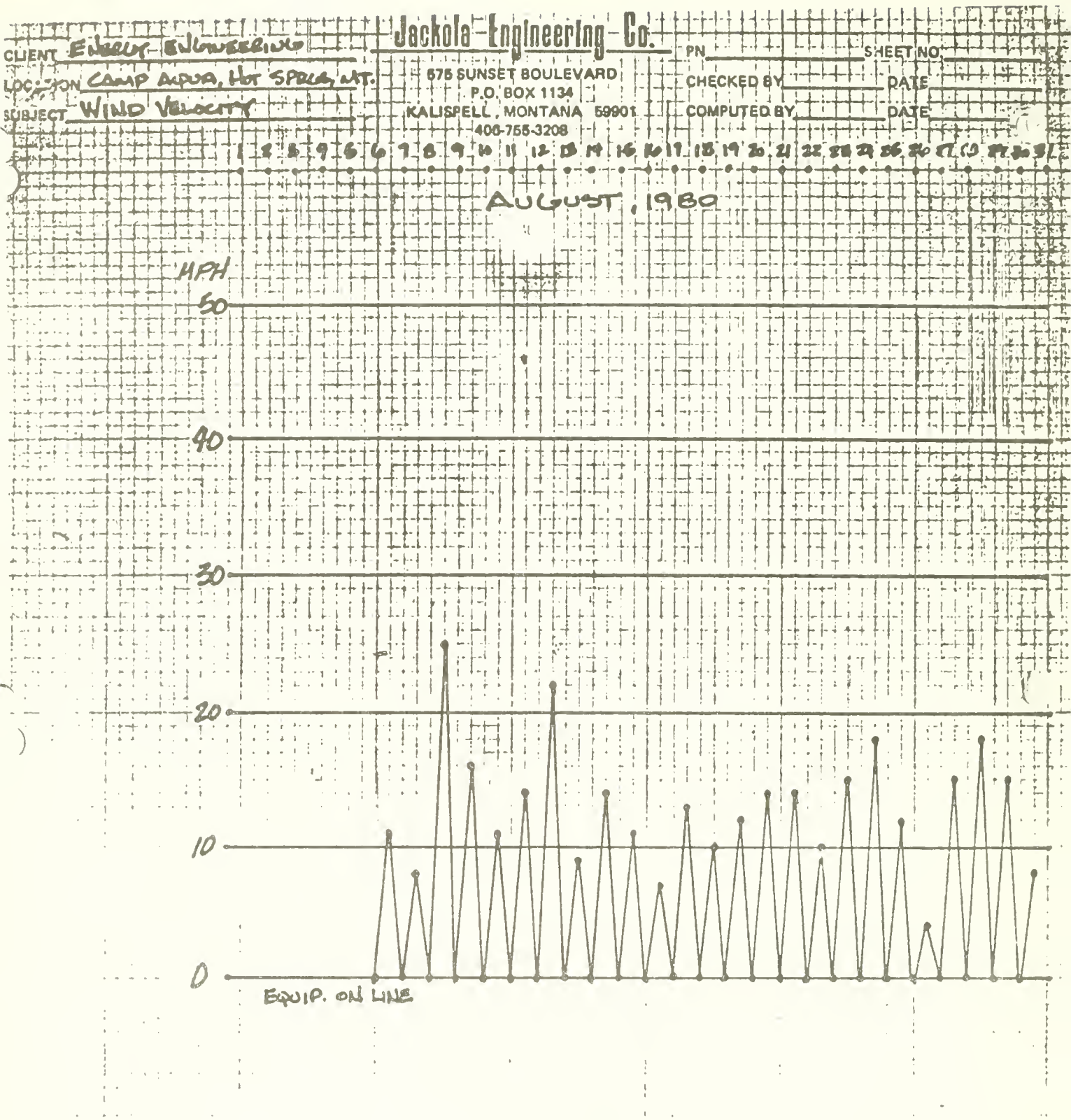
Jackola-Engineering-Co.

675 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

PN _____ SHEET NO. _____

CHECKED BY _____ DATE _____

COMPUTED BY _____ DATE _____



CLIENT ENERGY ENGINEERING

LOCATION CAMP AQUA, HOT SPRINGS, MT.

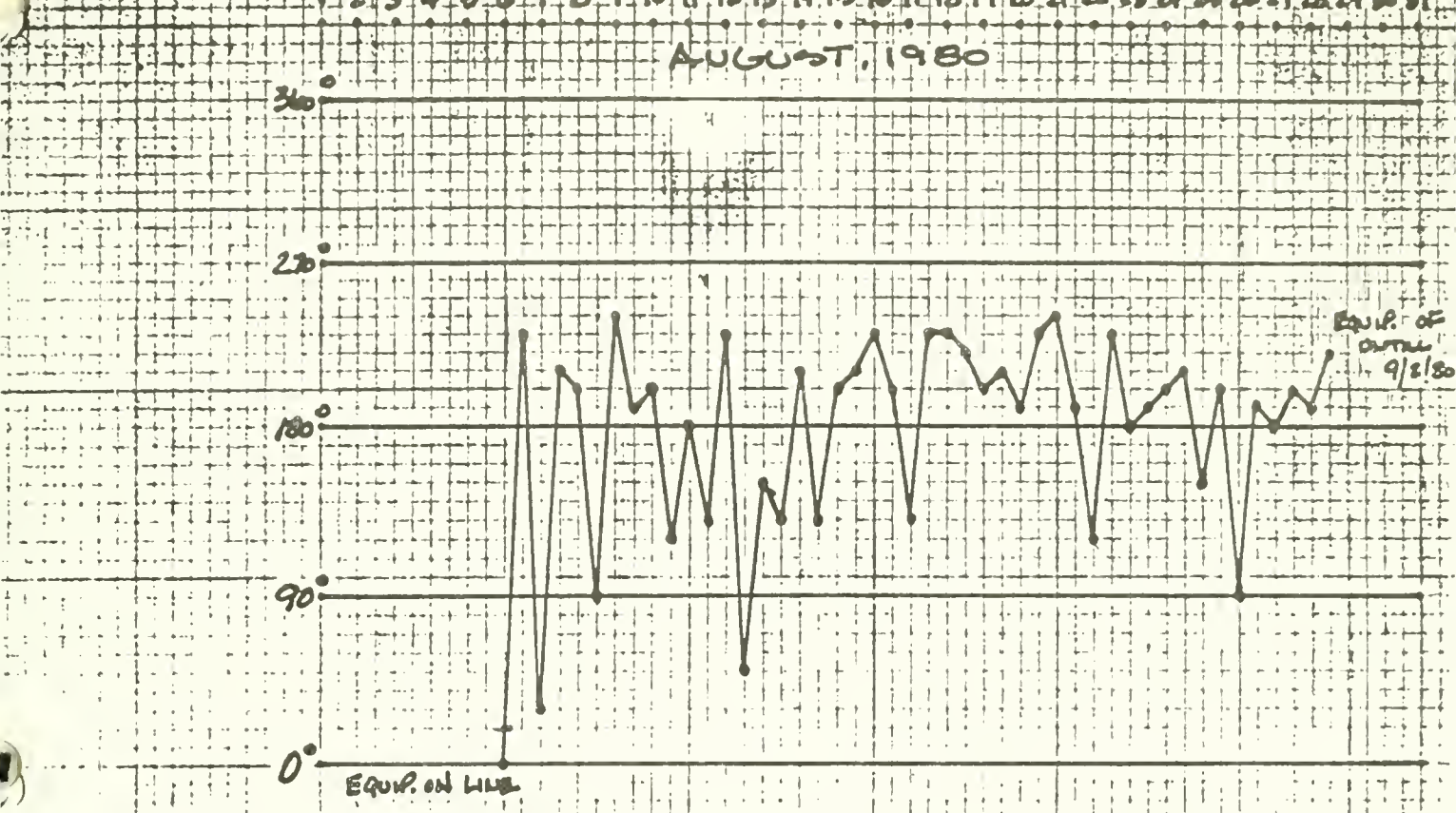
SUBJECT WIND DIRECTION

575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

PN _____ SHEET NO. _____

CHECKED BY _____ DATE _____

COMPUTED BY _____ DATE _____



SEPT. 80

CLIENT BURLOT ENGR. CO.

LOCATION CAMP AQUA HOT SPRINGS

SUBJECT TEMP.

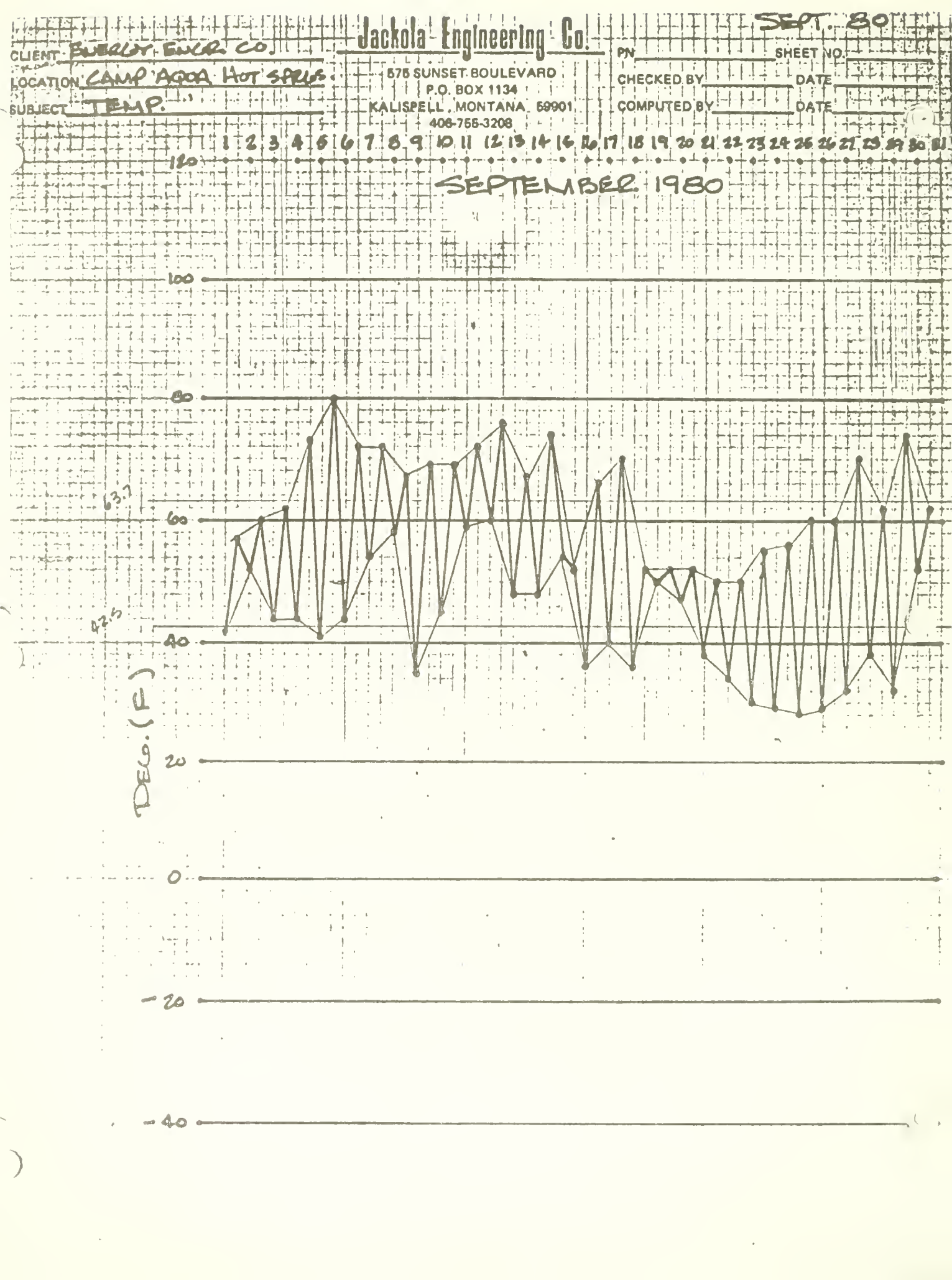
Jackola Engineering Co.

575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

PN _____ SHEET NO. _____

CHECKED BY _____ DATE _____

COMPUTED BY _____ DATE _____



CLIENT ENERGY ENGINEERING

LOCATION CAMP AQUA HOT SPRINGS.

SUBJECT HUMIDITY & BAROMETRIC PRESS.

Jackola Engineering Co.

575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

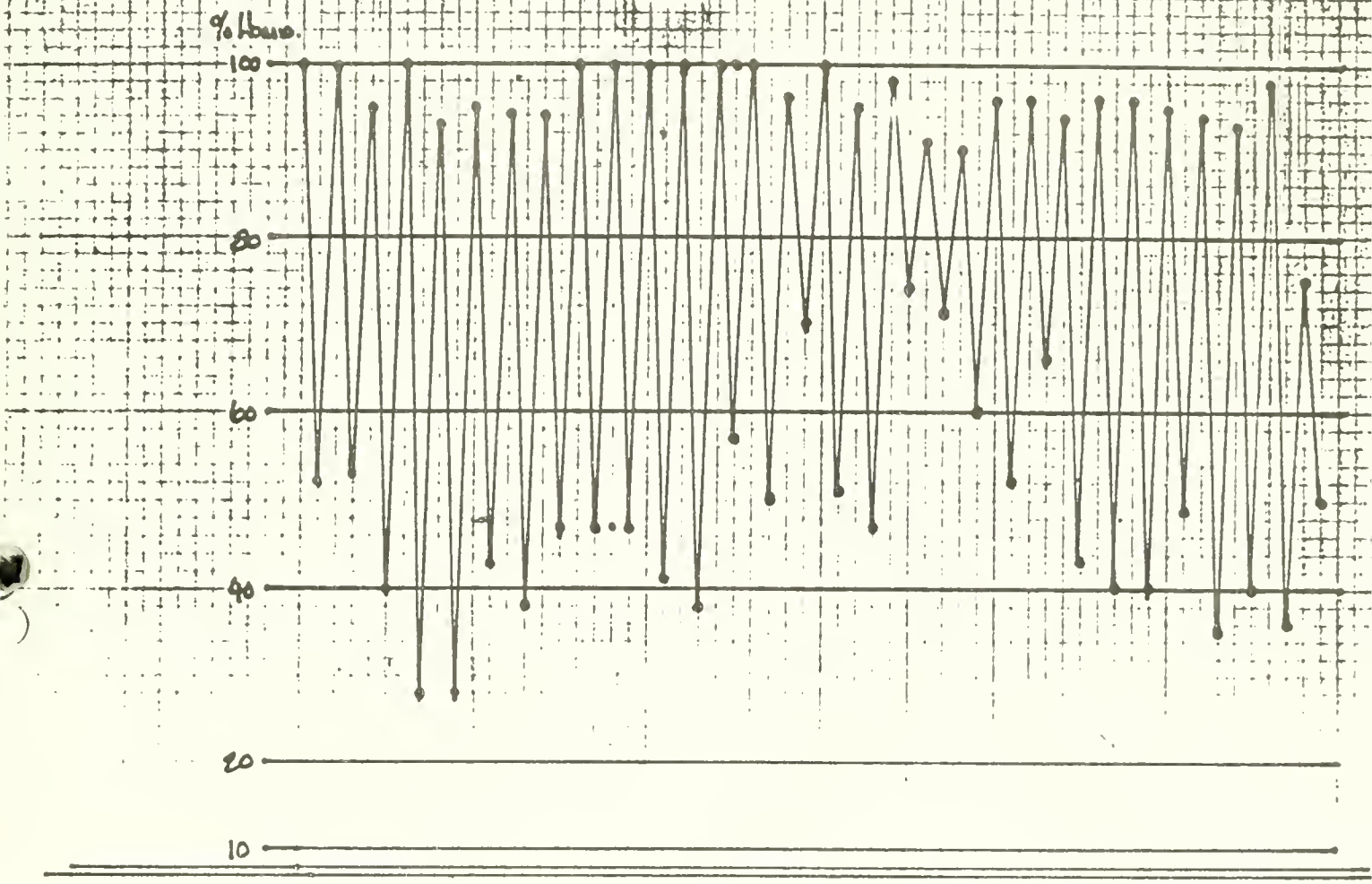
PN _____ SHEET NO. _____

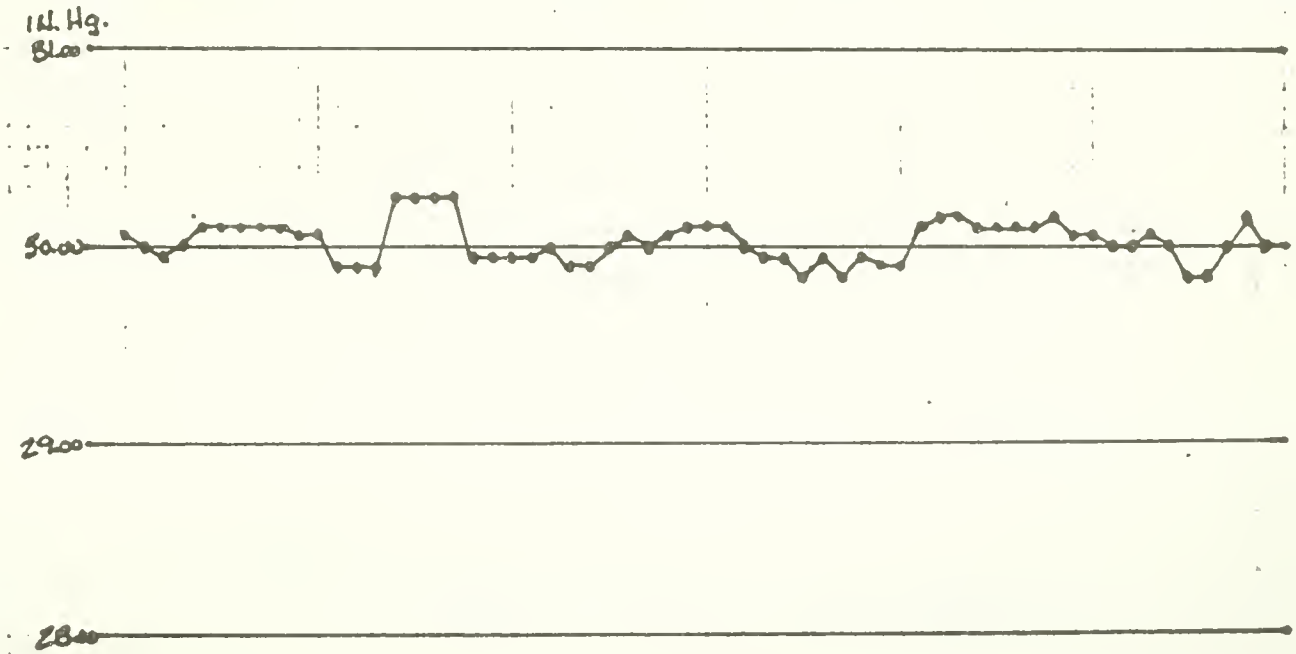
CHECKED BY _____ DATE _____

COMPUTED BY _____ DATE _____

SEPT. 80

SEPTEMBER 1980





Jackola Engineering Co.

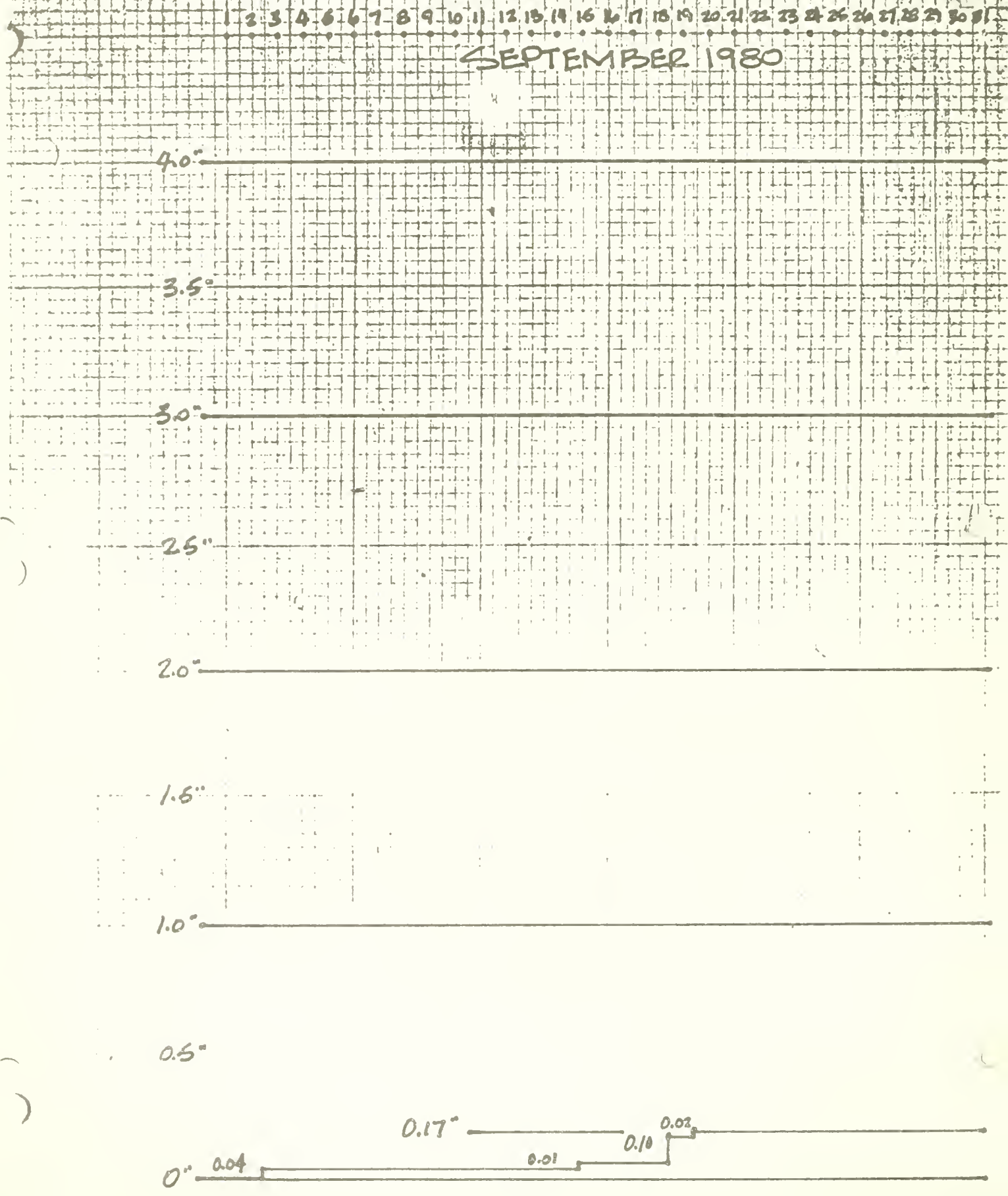
575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

CLIENT ENERGY ENGINEERING
LOCATION CAMP AQUA HOT SPRINGS
SUBJECT PRECIPITATION

PN
CHECKED BY
COMPUTED BY

SEPT. 80
SHEET NO.
DATE
DATE

SEPTEMBER 1980



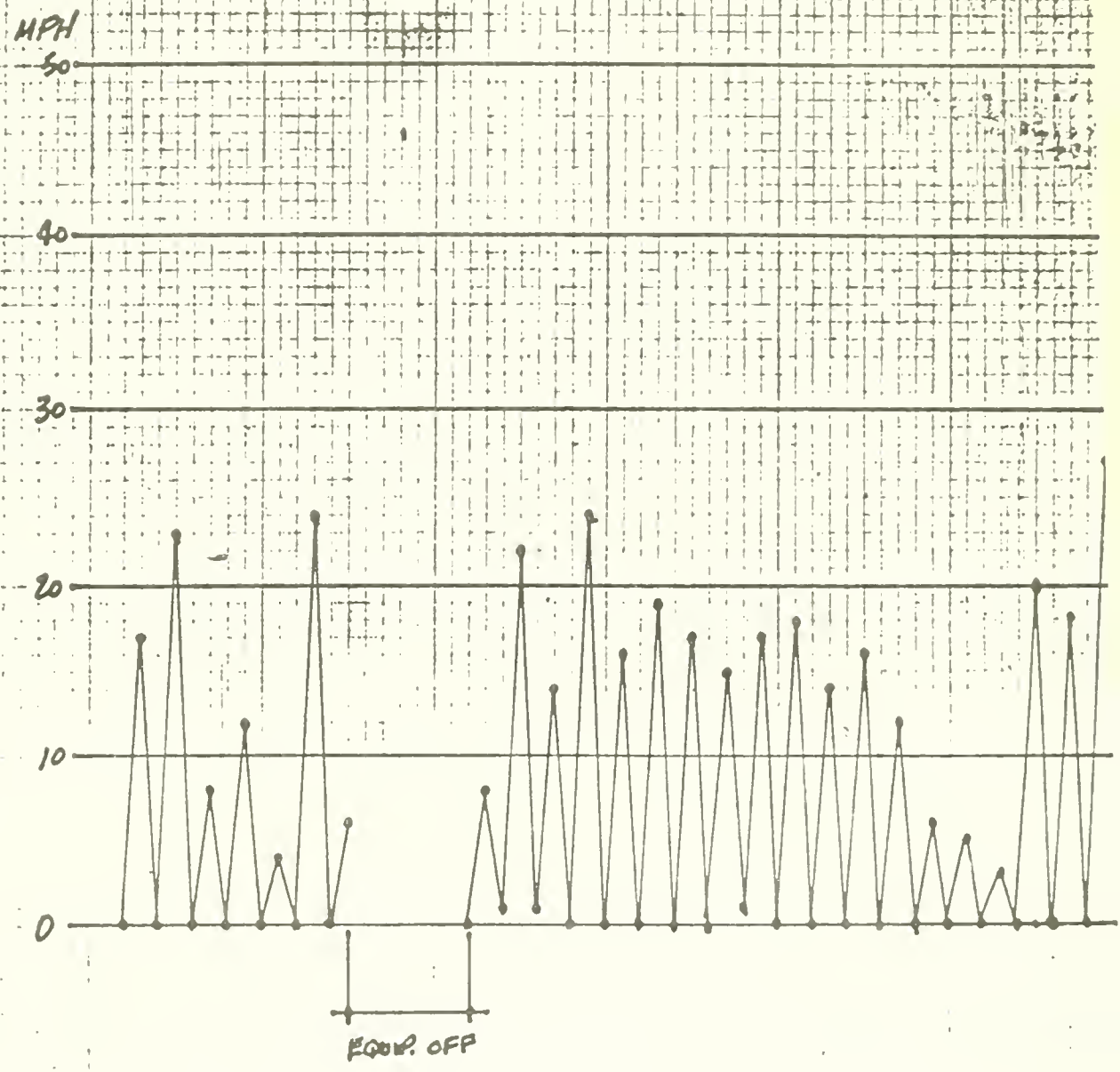
LOCATION CAMP AQUA, HOT SPRINGS, MT.

SUBJECT WIND VELOCITY

675 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

JOB NO. _____ SHEET NO. _____
CHECKED BY _____ DATE _____
COMPUTED BY _____ DATE _____

SEPT. 1980



CLIENT ENERGY ENGINEERING

LOCATION CALD AQUA, HOT SPRGS, MT.

SUBJECT WIND DIRECTION

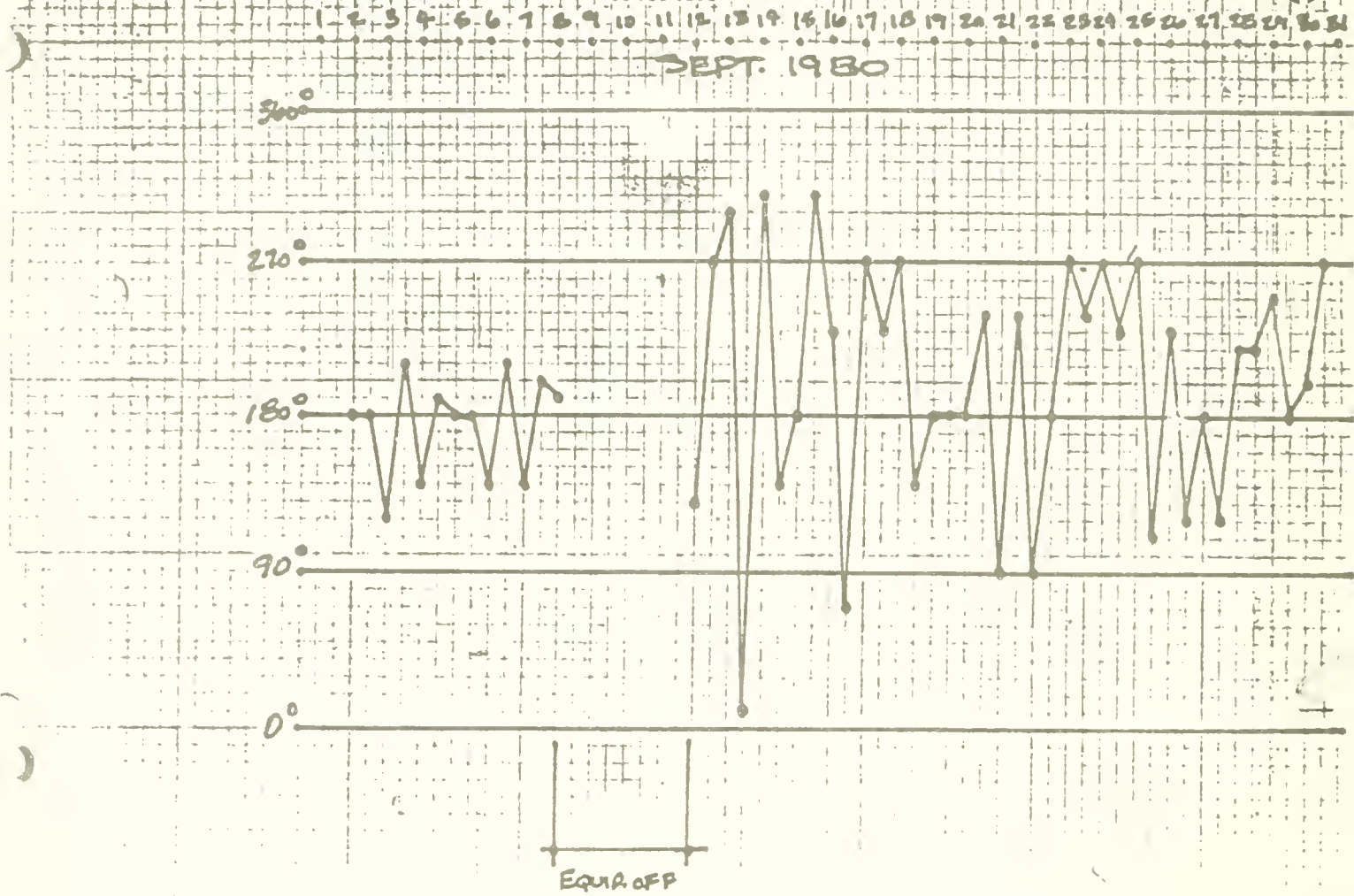
Jackola Engineering Co.

575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

PN _____ SHEET NO. _____

CHECKED BY _____ DATE _____

COMPUTED BY _____ DATE _____



IENT ENERGY ENGINEERING

Jackola Engineering Co.

575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

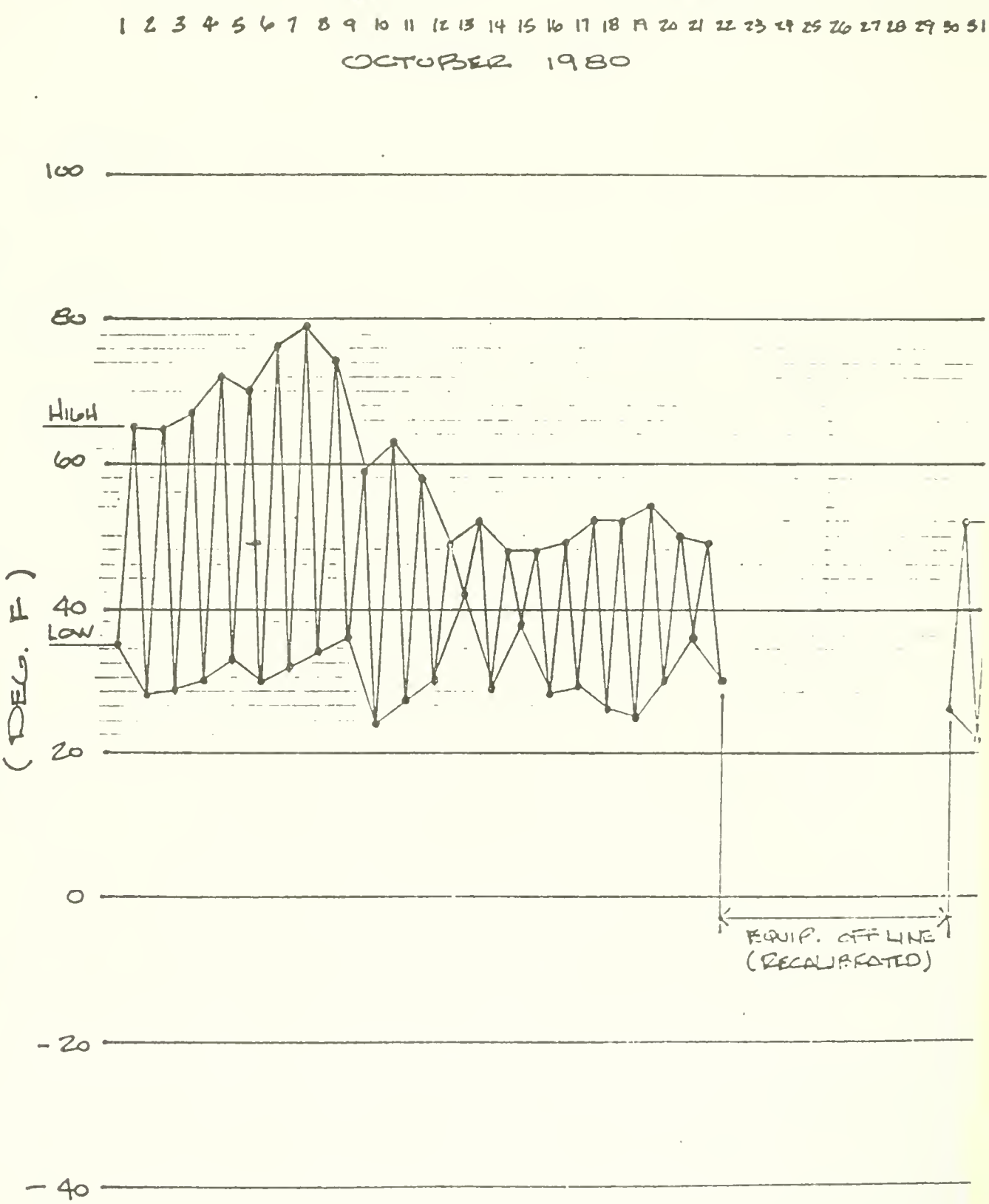
PN _____ SHEET NO. _____

CATION CAMP AQUA, HOT SPRINGS, MT.

CHECKED BY WNH DATE 11/12/80

JECT TEMP.

COMPUTED BY WNH DATE 11/12/80



CLIENT ENERGY ENGRG.

LOCATION CAMP AQUA, HOT SPRGS. MT.

SUBJECT HUMIDITY & BAROMETRIC PRESS.

DOUGLAS ENGINEERING CO.
575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

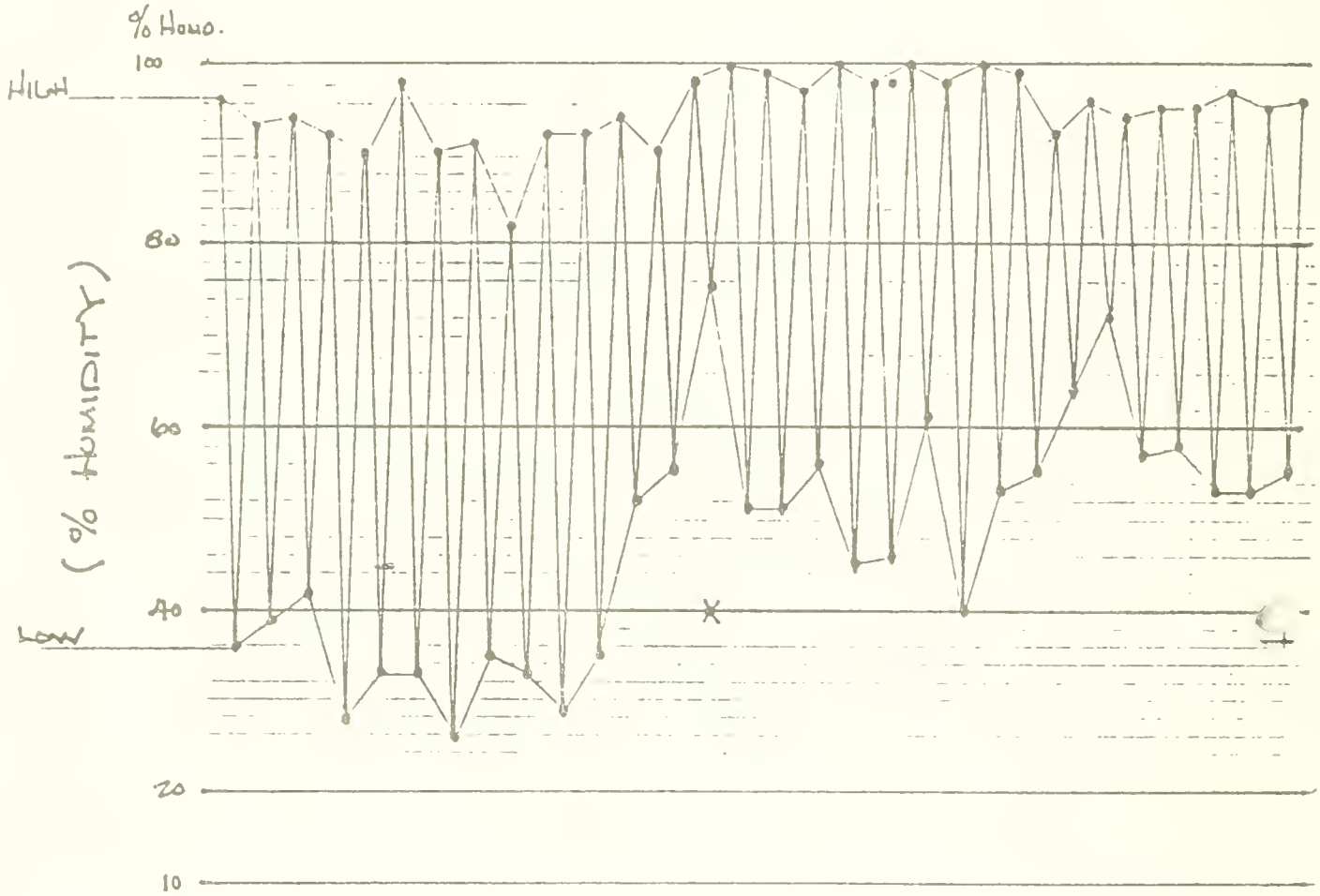
PN _____ SHEET NO. _____

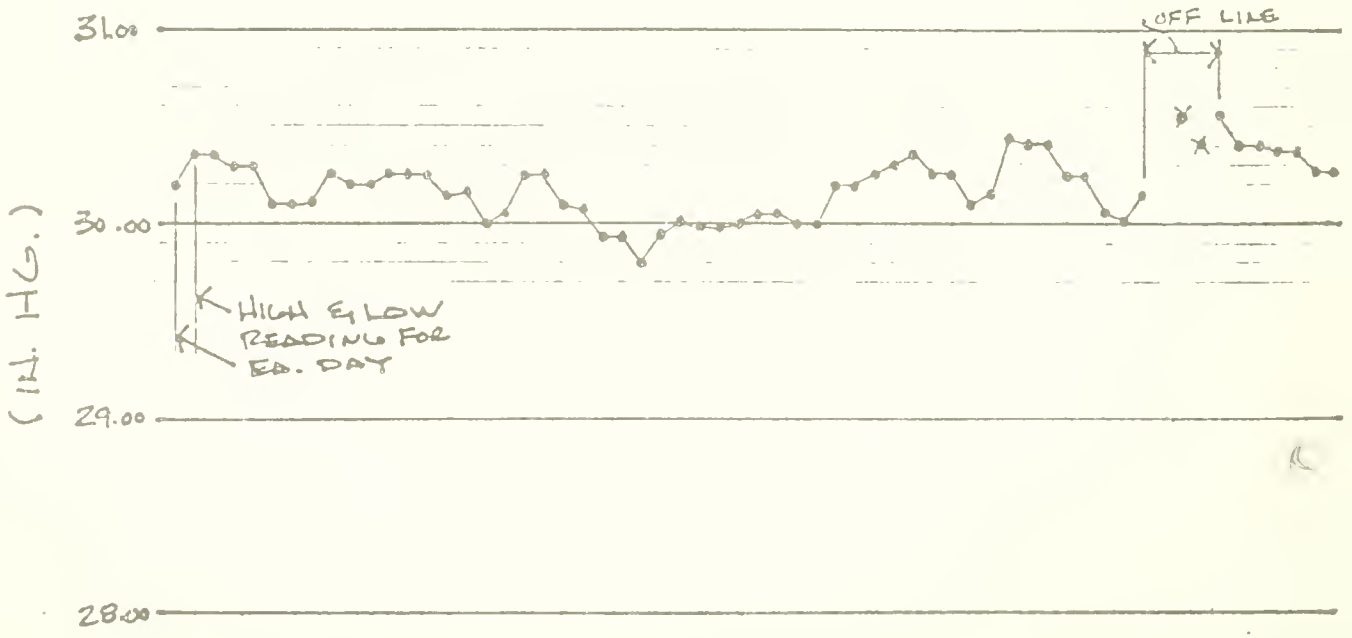
CHECKED BY WNB DATE 11/12/80

COMPUTED BY WNA DATE 11/12/80

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29

OCTOBER 1980



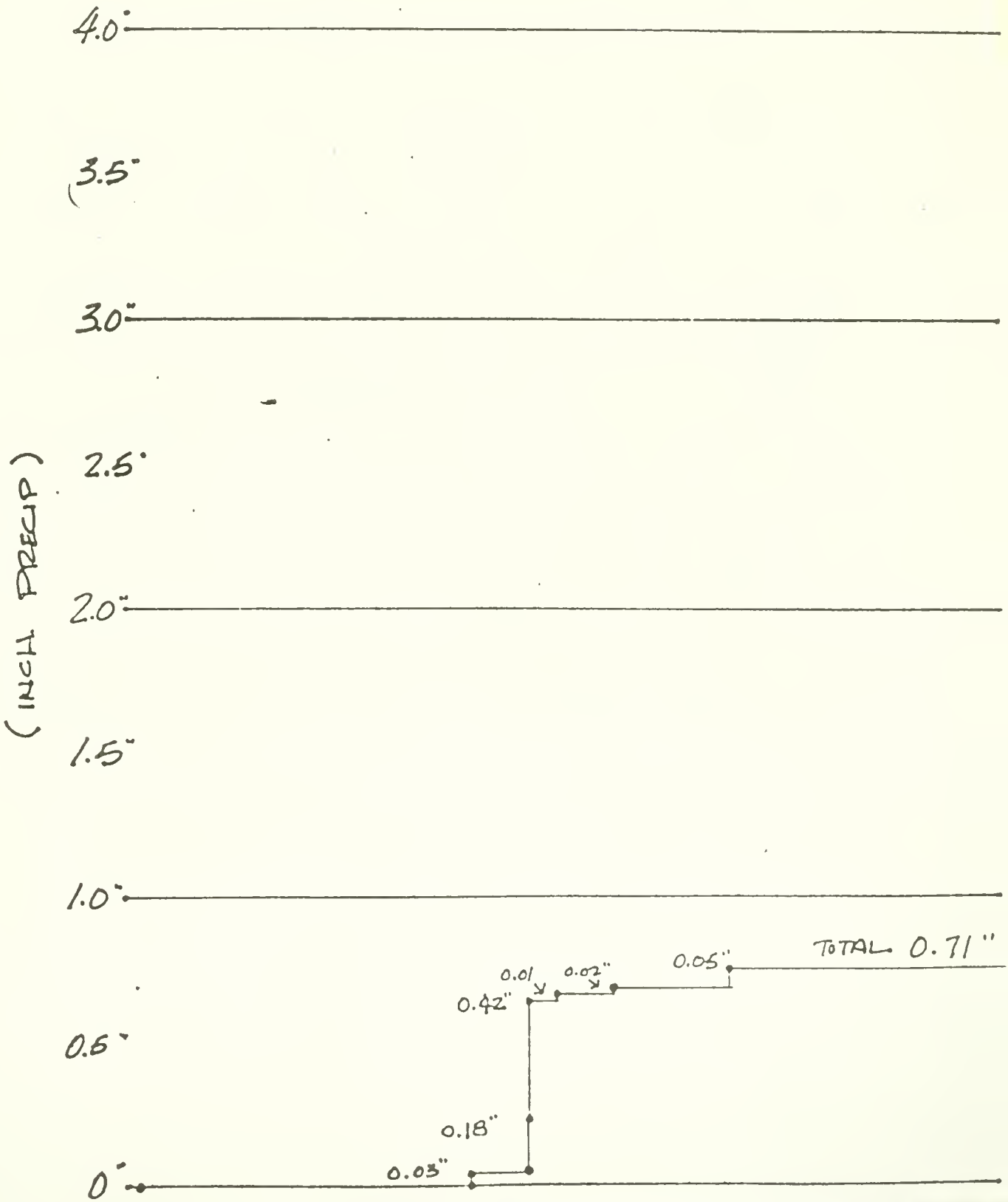


Jackola Engineering Co.
575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

CLIENT ENERGY ENGINEERING
LOCATION CAMP AQUA, HOT SPRINGS, MT.
SUBJECT PRECIPITATION

PN ____ SHEET NO. ____
CHECKED BY NNH DATE 11/13/80
COMPUTED BY WWH DATE 11/13/80

OCTOBER 1980



CLIENT: ENERGY ENGINEERING

LOCATION: CAMP AQUA, HOT SPRGS, MT.

SUBJECT: WIND VELOCITY

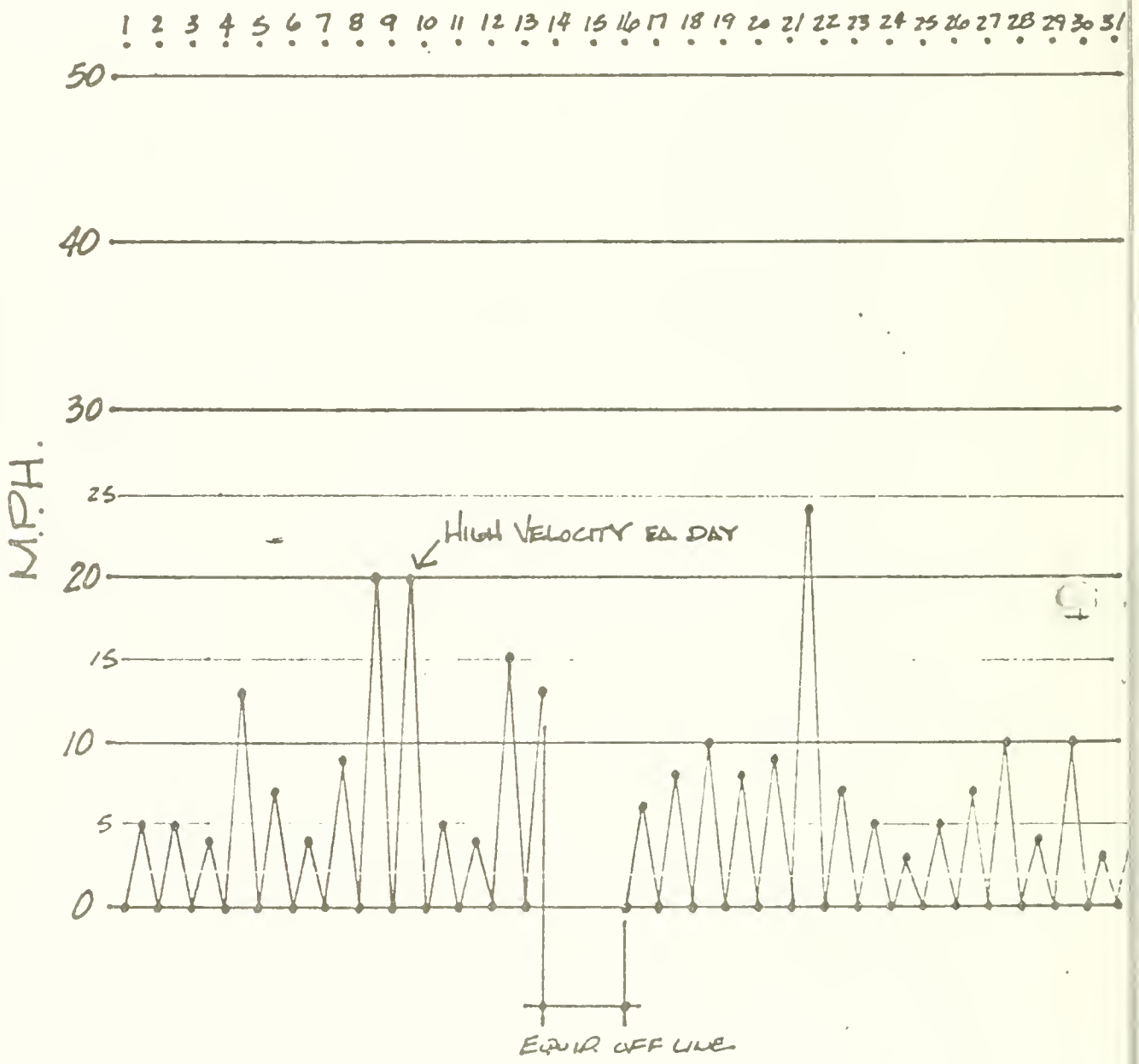
575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

PN _____ SHEET NO. _____

CHECKED BY WWH DATE 11/18/80

COMPUTED BY WWH DATE 11/18/80

OCTOBER 1980

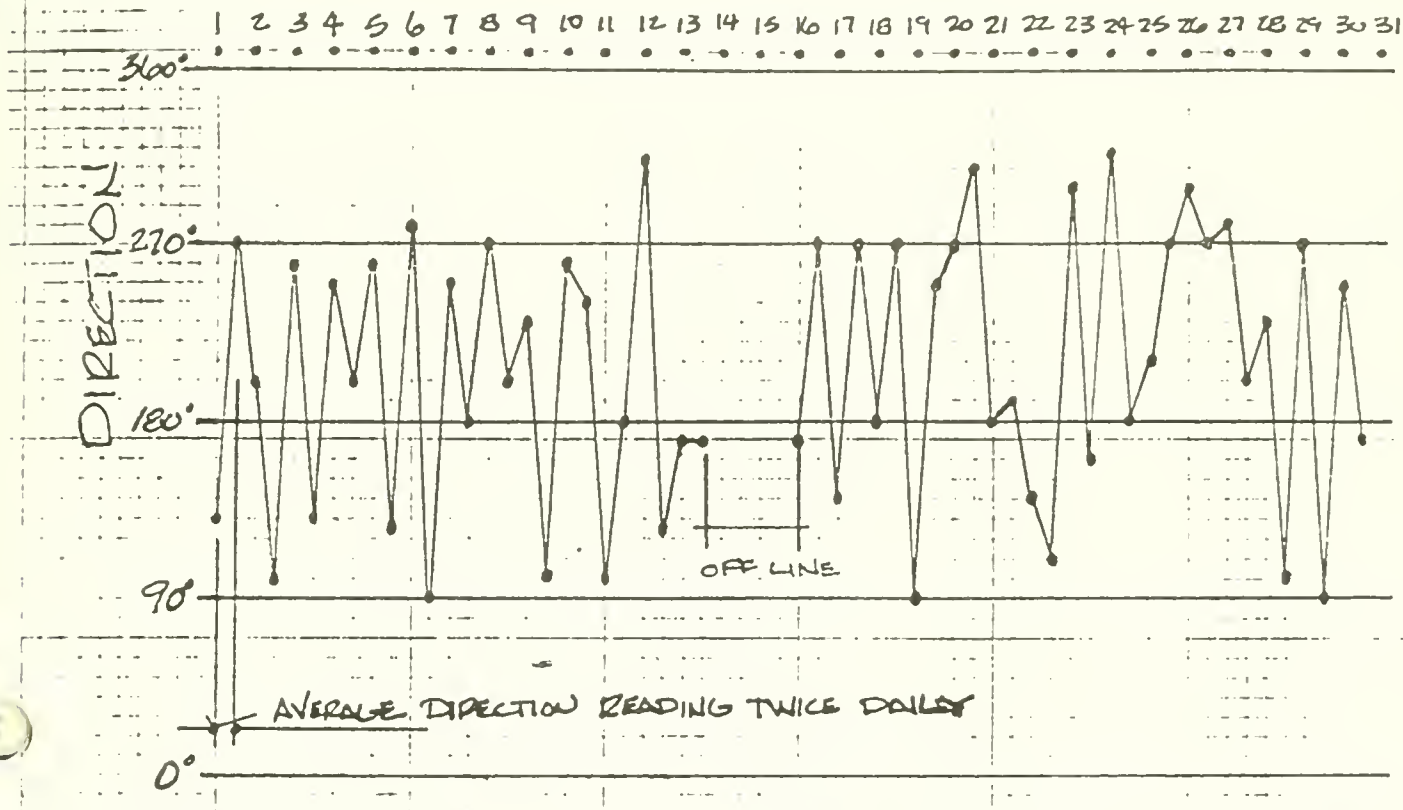


CATION CAMP-AQUA, HOT SPRGS, MT.
JECT WIND DIRECTION

575 SUNSET BOULEVARD
P.O. BOX 1134
KALISPELL, MONTANA 59901
406-755-3208

CHECKED BY WNH DATE 11/18/80
COMPUTED BY WNH DATE 11/18/80

OCTOBER 1980



M.E. LAB

MONTANA ENVIRONMENTAL LABORATORY

Certified by the Montana Department of Health and Environmental Sciences according to the Federal Drinking Water Standards

376 W. WASHINGTON
P O Box 1876
Kalispell, Montana 59901
Phone 755-2131

BACTERIOLOGICAL RESULTS RECEIVED JUN 1 1982

PRODUCTION WELL

ALL INFORMATION BELOW MUST BE FILLED IN

SAMPLE ADDRESS: CAMP AQUA

☐ Well, Depth of Well 261' 0"

Spring Cistern

☐ Lake or Other Surface Supply: _____

SAMPLED DATE: 6/10/82 TIME: 2:00 PM

COLLECTED BY: JACKOLA ENGR CO

MAIL REPORT TO

JACKOLA ENG. CO

MAIL SAMPLES MON. · TUES. · WED. ONLY

SAMPLING PROCEDURE

1. Remove screen. Allow water to run 2-3 minutes
2. Fill bottle to line, without touching inside of bottle or cap. Do not rinse out bottle
3. Fill out sampling information and return to lab within 48 hrs.
4. Payment of $ must accompany sample to be analyzed. Add $ for postage if mailed

LAB USE ONLY

RECEIVED AT LAB: 6-10-82 3:30

ANALYZED: 6-10 4:00

ANALYZED BY: _____

Lab No	Coliform Organisms per 100 ml		
	Satisfactory		Contaminated
415	X	<1	

Laucks
Testing Laboratories, Inc.
940 South Harney Street, Seattle, Washington 98108 (206) 767-5060
Chemistry, Microbiology, and Technical Services

Certificate

CLIENT Jackola Engineering
575 Sunset Boulevard
Kalispell, MT 59901

LABORATORY NO 76920

DATE July 15, 1982

REPORT ON WATER

SAMPLE IDENTIFICATION Marked: Camp Aqua 6/10/82 2:00 PM
PRODUCTION WELL

TESTS PERFORMED AND RESULTS

Methane, parts per million (mg/L) --------- 4.8

Respectfully submitted,

Laucks Testing Laboratories, Inc.

J. M. Owens

J. M. Owens

JMO:bg

This report is submitted for the exclusive use of the person, partnership or corporation to whom it is addressed. Subsequent use of the name of this company or any member of its staff in connection with the advertising or sale of any product or process will be granted only on contract. This company accepts no responsibility except for the due performance of inspection and/or analysis in good faith and according to the rules of the trade and of science.

MONTANA BUREAU OF MINES AND GEOLOGY
BUTTE, MONTANA 59701 (406)496-4101

WATER QUALITY ANALYSIS
LAB NO. 82R0355

STATE MONTANA
COUNTY LAKE
LATITUDE-LONGITUDE 473038'20"N 114034'12"W
SITE LOCATION 22N 23W 29 ACAB
UTM COORDINATES Z N E
MBMG SITE
TOPOGRAPHIC MAP HOT SPRINGS NE 7 1/2'
STATION ID 473828114341201
GEOLOGIC SOURCE 112GRAV* * * SAMPLE SOURCE WELL
DRAINAGE BASIN PL
LAND SURFACE ALTITUDE
AGENCY I SAMPLER MBMG*RAN
SUSTAINED YIELD 1100. GPM
BOTTLE NUMBER JACKOLA
YIELD MEAS METHOD OTHER
DATE SAMPLED 04 JUN 82
TOTAL DEPTH OF WELL 261.0 FT (R)
TIME SAMPLED 08:30 HOURS
SWL ABOVE( ) OR BELOW GS 6. FT (M)
LAB I ANALYST MBMG*RNA
CASING DIAMETER 10 IN (M)
DATE ANALYZED 07 JUL 82
CASING TYPE STEEL
SAMPLE HANDLING 3120
COMPLETION TYPE OO*
METHOD SAMPLED GRAB
PERFORATION INTERVAL 241 TO 251 FT (M)
WATER USE INDUSTRIAL

SAMPLING SITE JACKOLA AP.100 FT E. OF CAMP AQUA BATH SPA
GEOLOGIC SOURCE

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	2.9	0.14	BICARBONATE	(HCO3)	327.	5.36
MAGNESIUM	(MG)	.2	0.02	CARBONATE	(CO3)	11.0	0.37
SODIUM	(NA)	152.	6.61	CHLORIDE	(CL)	34.	0.96
POTASSIUM	(K)	3.1	0.08	SULFATE	(SO4)	.6	0.01
IRON	(FE)	<.002		NITRATE	(AS N)	.05	0.00
MANGANESE	(MN)	.009	0.00	FLUORIDE	(F)	5.0	0.26
SILICA	(SIO2)	43.2		PHOSPHATE TOT	(AS P)		
TOTAL CATIONS			6.85	TOTAL ANIONS			6.96

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.54

LABORATORY PH	8.53	TOTAL HARDNESS AS CACO3	8.06
FIELD WATER TEMPERATURE	51.0 C	TOTAL ALKALINITY AS CACO3	286.54
CALCULATED DISSOLVED SOLIDS	413.14	SODIUM ADSORPTION RATIO	23.29
SUM OF DISS. CONSTITUENT	579.06	RYZNAR STABILITY INDEX	8.33
SPEC.COND.(MICROMHOS/CM)	651.2	LANGLIER SATURATION INDEX	-0.05

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	14.0 C	CNDUCTVY,FIELD MICROMHOS	645.
FIELD PH	8.28	ALKALINITY,FLD(AS CACO3)	303.
CONDUCTVY,FIELD MICROMHOS	645.	ALUMINUM, DISS (MG/L-AL)	<.03
NICKEL,DISS (MG/L AS NI)	<.01	SILVER,DISS (MG/L AS AG)	<.002
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.54
STRONTIUM,DISS (MG/L-SR)	.10	CADMIUM,DISS(MG/L AS CD)	<.002
TITANIUM DIS(MG/L AS TI)	<.001	CHROMIUM, DISS (MG/L CR)	<.002
VANADIUM,DISS(MG/L AS V)	<.001	COPPER,DISS (MG/L AS CU)	<.002
ZINC,DISS (MG/L AS ZN)	<.004	LITHIUM,DISS(MG/L AS LI)	.070
ZIRCONIUM DIS(MG/L ZR)	<.003	MOLYBDENUM,DISS(MG/L MO)	<.02
ARSENIC,DISS(UG/L AS AS)	.2		

REMARKS: WATER CLEAR*SAMPLED WITH PLASTIC BUCKET*JACKOLA PRODUCTION WELL INTENDED FOR ALCHOL PLANT*WELL DETAILS FROM DRILLER*NIKE OSBOURNE* LIBERTY DRILLING*PADDLE WHEEL FLOWMETER

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVALENTS PER LITER, FT = FEET, MT = METERS, (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED, TR = TOTAL RECOVERABLE, TOT = TOTAL.

	QW	WA	S2	WI	OW	PW	AI	OTHER
OTHER AVAILABLE DATA							Y	

OTHER FILE NUMBERS:

PROJECT: COST:
LAST LOG DATE: 29 JUL 82 BY: TP *BCS
PROCESSING PROGRAM: F1ZAOP V2 (11/3/81) PRINTED: 02 AUG 82

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
2.1	0.2	96.5	1.2	14.3	0.2	80.0	5.5

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER: 82R0355

RECEIVED AUG - 7

BUTTE, MT 59701 (406)496 4101 LAB NO

STATE MONTANA COUNTY LAKE

LATITUDE-LONGITUDE 47D38'28"N 114D34'12"W SITE LOCATION 21N 23W 29 AD B

UTM COORDINATES Z N E MBMG SITE

TOPOGRAPHIC MAP HOT SPRINGS NE 7 1/2' STATION ID

GEOLOGIC SOURCE 112GRAV* * * SAMPLE SOURCE WELL 473828114341 20

DRAINAGE BASIN PL LAND SURFACE ALTITUDE

AGENCY + SAMPLER MBMG*RAN SUSTAINED YIELD 100. GPM

BOTTLE NUMBER JACKOLA YIELD MEAS METHOD DITCH

DATE SAMPLED 04-JUN-82 TOTAL DEPTH OF WELL 251.0 FT

TIME SAMPLED 08:30 HOURS SWL ABOVE(-) OR BELOW(+) 6. FT (M)

LAB + ANALYST MBMG*FNA CASING DIAMETER 10 IN (M)

DATE ANALYZED 07-JUL-82 CASING TYPE STEEL

SAMPLE HANDLING 3120 COMPLETION YEAR 08*

METHOD SAMPLED GRAB PERFORATION INTERVAL 241 TO 251 FT (M)

WATER USE INDUSTRIAL

SAMPLING SITE JACKOLA APPROX 100 FT EAST OF CAMP AQUA BATH SPA

GEOLOGIC SOURCE

		MG/L	MEQ/L			MG/L	MEQ/L
CALCIUM	(CA)	2.9	0.14	BICARBONATE	(HCO3)	327 ~~342~~	5.72
MAGNESIUM	(MG)	.2	0.02	CARBONATE	(CO3)	11.0	
SODIUM	(NA)	152.	6.61	CHLORIDE	(CL)	34.	0.96
POTASSIUM	(K)	3.1	0.08	SULFATE	(SO4)	.6	0.01
IRON	(FE)	<.002		NITRATE	(AS N)	.05	0.00
MANGANESE	(MN)	.009	0.00	FLUORIDE	(F)	5.0	0.26
SILICA	(SIO2)	43.2		PHOSPHATE TOT	(AS P)		

TOTAL CATIONS 6.85 TOTAL ANIONS 6.96

STANDARD DEVIATION OF ANION-CATION BALANCE (SIGMA) 0.51

LABORATORY PH	8.53	TOTAL HARDNESS AS CACO3	8.0
FIELD WATER TEMPERATURE	51.0 C	TOTAL ALKALINITY AS CACO3	286.2
CALCULATED DISSOLVED SOLIDS	412.98	SODIUM ADSORPTION RATIO	23.2
SUM OF DISS. CONSTITUENT	590.06	RYZNAR STABILITY INDEX	8.6
LAB SPEC.COND.(MICROMHOS/CM)	651.2	LANGLIER SATURATION INDEX	-0.0

PARAMETER	VALUE	PARAMETER	VALUE
TEMPERATURE, AIR (C)	14.0 C	CNDUCTVY,FIELD MICROMHOS	645.
FIELD PH	8.28	ALKALINITY,FLD(AS CACO3)	1516.
CNDUCTVY,FIELD MICROMHOS	645.	ALUMINUM, DISS (MG/L-AL)	<.0
NICKEL,DISS (MG/L AS NI)	<.01	SILVER,DISS (MG/L AS AG)	<.0
LEAD,DISS (MG/L AS PB)	<.04	BORON ,DISS (MG/L AS B)	.54
STRONTIUM,DISS (MG/L-SR)	.10	CADMIUM,DISS(MG/L AS CD)	<.002
TITANIUM DIS(MG/L AS TI)	<.001	CHROMIUM, DISS (MG/L-CR)	<.002
VANADIUM,DISS(MG/L AS V)	<.001	COPPER,DISS (MG/L AS CU)	<.002
ZINC,DISS (MG/L AS ZN)	<.004	LITHIUM,DISS(MG/L AS LI)	.078
ZIRCONIUM DIS(MG/L ZR)	<.003	MOLYBDENUM,DISS(MG/L-MO)	<.02
ARSENIC,DISS(UG/L AS AS)	.2		

REMARKS: WATER CLEAR*SAMPLED WITH PLASTIC BUCKET*JACKOLA PRODUCTION WELL INTENDED FOR ALCHOL PLANT*WELL DETAILS FROM DRILLER*MIKE OSBOURNE LIBERTY DRILLING*PADDLE WHEEL FLOWMETER

EXPLANATION: MG/L = MILLIGRAMS PER LITER, UG/L = MICROGRAMS PER LITER, MEQ/L = MILLIEQUIVELENTS PER LITER. FT = FEET, MT = METERS. (M) = MEASURED, (E) = ESTIMATED, (R) = REPORTED. TR = TOTAL RECOVERABLE. TOT = TOTAL.

	QW	WA	S2	WI	OW	PW	AT	OTHER
OTHER AVAILABLE DATA							Y	

OTHER FILE NUMBERS:

PROJECT: COST:

LAST EDIT DATE: 08-JUL-82 BY: TF *INS

PROCESSING PROGRAM: F1730P V2 (11/3/81) PRINTED: 09 JUL 82

PERCENT MEQ/L (FOR PIPER PLOT)

CA	MG	NA	K	CL	SO4	HCO3	CO3
2.1	0.2	96.5	1.2	14.3	0.2	85.5	0.0

Group Name 82MOST

NOTE: IN CORRESPONDENCE, PLEASE REFER TO LAB NUMBER 820355

MONTANA BUREAU OF MINES AND GEOLOGY

PRELIMINARY — SUBJECT TO REVISION

MONTANA BUREAU OF MINES AND GEOLOGY

PRELIMINARY — SUBJECT TO

Print ?

Corrections

SIERRA ENVIRONMENTAL MONITORING

GENERAL MINERAL ANALYSIS REPORT

State of Nevada Certified
Laboratory No. 11

DATE OF REPORT MON	DAY	YR.	JOB NUMBER
2/11/82			SN 907 722

CLIENT: Wm. E. Nork, Inc.
1026 West First Street
Reno, NV 89503

SAMPLE IDENTIFICATION DATA

IDENTIFICATION NUMBER: CAT-1
SAMPLE COLLECTION DATE: 1/29/82
SAMPLE COLLECTION TIME: 11:10 Hours
SAMPLE COLLECTED BY: Dale Bugenig
SAMPLING LOCATION: Camp AQUA
Lake County, Montana

PARAMETER		VALUE	CRITERIA	PARAMETER		VALUE	CRITERIA
BICARBONATE ALKALINITY	mg/l	272	—	MANGANESE	mg/l	0.05	0.10 2
CARBONATE ALKALINITY	mg/l	0	—	NITRATE NO_3	mg/l	0.1	45 1
CALCIUM	mg/l	4.6	—	PH		8.2	6.5 – 8.5 2
CHLORIDE	mg/l	34	400 2	SODIUM	mg/l	145	—
ARSENIC	mg/l	0.04	0.05	SULFATE	mg/l	5	500 2
FLUORIDE	mg/l	5.5	* 1	TOTAL DISSOLVED SOLIDS	mg/l	423	1000 2
IRON	mg/l	0.79	0.6 2	Potassium ~~TOTAL HARDNESS~~	mg/l	3.3	—
MAGNESIUM	mg/l	0.8	150 2	Silica	mg/l	42	
				Zinc	mg/l	<0.01	

OTHER WATER QUALITY ANALYSIS REQUESTED

Boron	mg/l			Lithium	mg/l	<0.05	
Cadmium	mg/l	<0.01		Mercury	mg/l	<0.0005	
Chromium	mg/l	<0.02		Selenium	mg/l	<0.005	
Lead	mg/l	<0.05		Silver	mg/l	<0.01	

* CRITERIA DEPENDENT ON LOCAL ANNUAL AVERAGE MAXIMUM DAILY TEMPERATURES

1. U.S. ENVIRONMENTAL PROTECTION AGENCY PRIMARY DRINKING WATER STANDARDS.
2. STATE OF NEVADA DIVISION OF HEALTH SECONDARY DRINKING WATER STANDARDS.

Laucks
Testing Laboratories, Inc.
[illegible] Western Avenue Seattle Washington 98104 (206) 622-0727
Chemistry Microbiology and Technical Services

RECEIVE
JUL 28
[illegible]spell, Montana 59901

Certificate

AGENT Jackola Engineering Co.
575 Sunset Boulevard
Kalispell, MT 59901

LABORATORY NO. 70646

DATE July 22, 19

REPORT ON WATER

SAMPLE IDENTIFICATION The following samples were composited to make one sample.

#1 7-1-80 5:00 PM Well Water
Hot Springs, MT Temp. 114°F

#2 7-1-80 6:00 PM Well Water
Hot Springs, MT Temp. 114°F

TESTS PERFORMED AND RESULTS

pH, glass electrode at 25°C	8.6
	parts per million
Total Iron	9.7
Potassium	.8
Sodium	140
Calcium	2.6
Magnesium	.3
Hardness as $CaCO_3$	280
Sulfate as SO_4	10
Total Alkalinity as $CaCO_3$	298
Carbonate Alkalinity as $CaCO_3$	0
Bicarbonate Alkalinity as $CaCO_3$	298
Hydroxide	0
Carbon Dioxide	1.3
Total Solids	540
Methane	Less/5
Ethane	Less/5
Propane	Less/5
Butane	Less/5

Respectfully submitted,

Mike Nelson

MN:ks

This report is submitted for the exclusive use of the person, partnership or corporation to whom it is addressed. Subsequent use of the name of this company or any member of its staff in connection with the advertising or sale of any product or process will be granted only on contract. This company accepts no responsibility except for the due performance of inspection and/or analysis in good faith and according to the rules of the trade and of science.

Laucks
Testing Laboratories, Inc.
1335 Western Avenue, Seattle Washington 98104 (206) 622-0727
Chemistry Microbiology and Technical Services

RECEIVED JUL 24

Certificate

CLIENT Jackola Engineering Co.
575 Sunset Boulevard
Kalispell, MT 59901

LABORATORY NO. 70745

DATE July 21, 198

REPORT ON WATER

SAMPLE IDENTIFICATION Marked: Well tap Camp Aqua Hot Springs MT
7/14/80 11:18 Bill Hallstrom

TESTS PERFORMED AND RESULTS

Methane, % wt/wt	.02
Propane, parts per million	<5
Ethane, parts per million	<5
Butanes, parts per million	<5

Explanation of Symbols

< denotes "less than"

MN:bg

RESPECTFULLY SUBMITTED,
Laucks Testing Laboratories, Inc.

DEARBORN CHEMICAL (U.S.)
CHEMED CORPORATION
GENESEE ST. • LAKE ZURICH, IL 60047
TELEPHONE 312/438-8241

Laboratory no. 65332 ID no. 26040000

Collected 07/24/86 Rec'd. 08/11/86 Reported 08/12/

Salesman J A JOHNSON District PAC NORTHWES

Client CAMP AQUA - HOT SPRING MT

Sampling Point WELL TAP

REPORT OF WATER ANALYSIS

PHYSICAL APPEARANCE

GT PLS CLS CLR

				PARTS PER MILLION (mg/l)*	EQUIVALENTS PER MILLION (me/l)**
Total dissolved solids*	458	ppm	CALCIUM as Ca	2.8	.14
Suspended solids*	<10	ppm	MAGNESIUM as Mg	.49	.04
Chloroform extractable (oil, etc.)		ppm	SODIUM and POTASSIUM as Na	153	6.65
pH	8.5		ALUMINUM as Al	<0.05 TOT	
Phenolphthalein alkalinity as $CaCO_3$	14	ppm	COPPER as Cu	<0.02 TOT	
Methyl orange alkalinity as $CaCO_3$	292	ppm	IRON as Fe	<0.05 TOT	
Hydroxide alkalinity as $CaCO_3$		ppm	MANGANESE as Mn	<0.05 TOT	
Total hardness as $CaCO_3$	9	ppm	ZINC as Zn	<0.05 TOT	
Specific conductance		micromhos per cm			
Turbidity		units	SILICA as SiO_2	46	
*Gravimetric, dried at 103-105°C			BICARBONATE as HCO_3	322	5.28
			CARBONATE as CO_3	16.8	.56
			HYDROXIDE as OH		
			CHLORIDE as Cl	34	.96
			SULFATE as SO_4	2	.04
			NITRATE as NO_3	< .5	
			NITRITE as NO_2		
			PHOSPHATE, ORTHO as PO_4		
			PHOSPHATE, POLY as PO_4		
			SULFITE as SO_3		
			CHROMATE as CrO_4		

SPECIAL ANALYSIS AND REMARKS:

BM/RL/dg

2 Copies on of West • River (Tree Out) Sorry For The delay due to Shipping difficulties. Contact me if any Further Test Analyses & Al Cu Fe Mn Zn are needed!

DOUBLE RUSH!

conversion factors
Parts per million x .0583 = gr./U.S. Gal
Grains per U.S. Gallon x 17.12 = ppm

*Parts per million (ppm) = milligrams per liter (mg/l)
**Equivalents per million (epm) = milliequivalents per liter (me/l)

DEARBORN CHEMICAL (U.S.)
CHEMED CORPORATION
ENESEE ST. • LAKE ZURICH, IL 60047
TELEPHONE 312/438-8241

Laboratory no. PD no.

Collected 07/24/80 Rec'd. 08/04/80 Reported 08/13/80

Salesman J JOHNSON District PAC NORTHWEST

Client JACKOLA ENGR CO - KALISPELL MT

Sampling Point RIVER WATER OUT FLOW

REPORT OF WATER ANALYSIS

YSICAL APPEARANCE
-T PLS LT BRN SL BRN SED CLDY

al dissolved ds*	292	ppm
pended solids*	52	ppm
oroform ractable (oil, etc.)		ppm
	8.2	
enolphthalein alinity as $CaCO_3$	NONE	ppm
thyl orange alinity as $CaCO_3$	204	ppm
roxide nity as $CaCO_3$		ppm
dness as $CaCO_3$	122	ppm
cific ductance		micromhos per cm
ity		units
[illegible] at 103-105°C		

SPECIAL ANALYSIS AND REMARKS:

	PARTS PER MILLION (mg/l)*	EQUIVALENTS PER MILLION (me/l)**
CALCIUM as Ca	30	1.5
MAGNESIUM as Mg	11.2	.92
SODIUM and POTASSIUM as Na	50	2.17
ALUMINUM as Al		
COPPER as Cu		
IRON as Fe		
MANGANESE as Mn		
ZINC as Zn		
SILICA as SiO_2	42	
BICARBONATE as HCO_3	249	4.08
CARBONATE as CO_3	NONE	
HYDROXIDE as OH		
CHLORIDE as Cl	7.3	.21
SULFATE as SO_4	13	.27
NITRATE as NO_3	1	.02
NITRITE as NO_2		
PHOSPHATE, ORTHO as PO_4		
PHOSPHATE, POLY as PO_4		
SULFITE as SO_3		
CHROMATE as CrO_4		

onversion factors
Parts per million x .0583 = gr./U.S. Gal.

*Parts per million (ppm) = milligrams per liter (mg/l)
**[illegible] per million (ppm) = milligram [illegible] per liter (me/l)

DEARBORN CHEMICAL (U.S.)
CHEMED
GENESEE ST. • LAKE ZURICH, IL 60047
TELEPHONE 312/438-8241

Laboratory no. 85201 ID no. 26040003

Collected 07/24/80 Rec'd. 08/05/80 Reported 08/13/

Salesman J JOHNSON District PAC NORTHWES

Client JACKOLA ENG CO - KALISPELL MT

Sampling Point RIVER WATER IN COMING

REPORT OF WATER ANALYSIS

HYSICAL APPEARANCE

RT FLS LT BROWN SL BROWN SED CLDY

tal dissolved lids*	294	ppm
spended solids*	36	ppm
loroform tractable (oil, etc.)		ppm
H	8.3	
enolphthalein kalinity as $CaCO_3$	NONE	ppm
ethyl orange kalinity as $CaCO_3$	202	ppm
d oxide linity as $CaCO_3$		ppm
rdness as $CaCO_3$	128	ppm
ecific nductance		micromhos per cm
rbidity		units
ve ric, fried at 103-105°C		

SPECIAL ANALYSIS AND REMARKS:

DB/DG

	PARTS PER MILLION (mg/l)‡	EQUIVALENTS PER MILLION (me/l)‡‡
CALCIUM as Ca	32	1.6
MAGNESIUM as Mg	11.7	.96
SODIUM and POTASSIUM as Na	46	2
ALUMINUM as Al		
COPPER as Cu		
IRON as Fe		
MANGANESE as Mn		
ZINC as Zn		
SILICA as SiO_2	23	
BICARBONATE as HCO_3	247	4.05
CARBONATE as CO_3	NONE	
HYDROXIDE as OH		
CHLORIDE as Cl	6.7	.19
SULFATE as SO_4	14	.29
NITRATE as NO_3	1	.02
NITRITE as NO_2		-
PHOSPHATE, ORTHO as PO_4		
PHOSPHATE, POLY as PO_4		
SULFITE as SO_3		
CHROMATE as CrO_4		

onversion factors
Parts per million x .0583 = gr./U.S. Gal.
per U.S. Gallon x 17.12 = ppm

‡Parts per million (ppm) = milligrams per liter (mg/l)
‡‡Equivalents per million (epm) = milliequivalents per liter (me/l)

DEARBORN LABORATORIES

Laucks
Testing Laboratories, Inc.
Western Avenue Seattle Washington 98104 (206)622-0727
Microbiology and Technical Services

Certificate

Jackola Engineering Co.
175 Sunset Boulevard
Kalispell, MT 59901

LABORATORY NO 70865

DATE Aug. 15, 1980

REPORT ON WATER

SAMPLE IDENTIFICATION

Marked: 1) Well Trap Geothermal Sample #3 117°F
12.5 PSI 7/25/80 12:45
Camp Aqua, Hot Springs, MT
Sampled by: B. Hallstrom

TESTS PERFORMED AND RESULTS

2) River Water Out-flow Sample #5
Little Bitterroot 7/25/80 12:00
Camp Aqua, Hot Springs, MT
Sampled by: B. Hallstrom

3) River Water In-Flow Sample #5
Little Bitterroot 7/25/80 1:30
Camp Aqua, Hot Springs, MT
Sampled by: B. Hallstrom

	1	2	3
pH, glass electrode at 25°C	8.5	---	---
Color, units	5	---	---
Odor, Threshold Odor Number	1	---	---
Nephelometer Turbidity, units	<.5	---	---
	parts per million		
Carbon dioxide	1.4	---	---
Total Hardness	8	---	---
Total Alkalinity as $CaCO_3$	290	---	---
Hydroxide Alkalinity	0	---	---
Carbonate Alkalinity as $CaCO_3$	30	---	---
Bicarbonate Alkalinity as $CaCO_3$	260	---	---
Bromide	<.1	---	---
Chloride	32	---	---
Fluoride	5	---	---
Iodide	<.1	---	---
Nitrate	<.05	.3	.3
Nitrite	<.005	.010	.010
Total Phosphate	<.02	.15	.16
Sulfate as SO_4	2	---	---

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To Tola Engineering Co.

LABORATORY NO 70865

	parts per million		
	1	2	3
Sulfide	6	---	---
Sulfite as SO_3	<2	---	---
Sodium	140	---	---
Potassium	4.3	---	---
Calcium	2.9	---	---
Magnesium	.4	---	---
Aluminum	.05	1.5	1.3
Antimony	.13	.15	.12
Arsenic	<.005	<.005	<.005
Barium	<.02	.14	.14
Cadmium	<.002	<.002	<.002
Chromium	.025	.017	.012
Copper	.006	.011	.008
Ferric Iron	<.01	---	---
Ferrous Iron	<.05	---	--
Lead	<.05	<.05	<.05
Mercury	<.001	<.001	<.001
Nickel	<.05	<.05	<.05
Silver	<.002	<.002	<.002
Strontium	.14	.18	.19
Tin	<.005	<.005	<.005
Zinc	.008	.018	.032
Ammonia as NH_3	---	.2	1.0
Total Kjeldahl Nitrogen	---	1.3	2.2
Iron	---	1.3	1.3
	MPN per 100 mls		
Total Coliform	<2	170	170
Fecal Coliform	<2	79	17

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Lauck's
Testing Laboratories, Inc.
1008 Western Avenue, Seattle, Washington 98104 (206) 622-0727
Chemistry, Microbiology, and Technical Services

Certificate

LABORATORY NO. 70865

[illegible] Engineering Co.

Explanation of Symbols

< denotes "less than"

Respectfully submitted,

Lauck's Testing Laboratories, Inc.

J. M. Owens

J. M. Owens

SMQ:bg Submitted for the exclusive use of the person, partnership or corporation to whom it is addressed. Subsequent use of the name of this company or any member of its staff in connection with the advertising or sale of any product or process will be granted only on contract. This company accepts no responsibility except for the due performance of inspection and/or analysis in good faith and according to the rules of the trade and of science.

Lauers
Testing Laboratories, Inc.
1808 Western Avenue Seattle Washington 98104 (206) 622 0727

Certificate

Chemistry Microbiology and Technical Services

Kalispell, Mont. 59901

CLIENT Jackola Engineering Co.
575 Sunset Boulevard
Kalispell, MT 59901

LABORATORY NO 70934

DATE Aug. 28, 1980

REPORT ON WATER

SAMPLE IDENTIFICATION Marked:

1) Geothermal 118°F 12PSI Sample #7
Location: Camp Aqua-Hot Springs, MT
Sampled by: B. Hallstrom Date: 8-1-80 11:00 AM

2) River in-flow Sample #8
Location: Camp Aqua-Hot Springs, MT
Sampled by: B. Hallstrom Date: 8-1-80 9:30 AM

3) River out-flow Sample #9
Location: Camp Aqua-Hot Springs, MT
Sampled by: B. Hallstrom Date: 8-1-80 10:00 AM

TESTS PERFORMED AND RESULTS

	1	2	3
pH, glass electrode at 25°C	8.5	---	---
Color, units	5	----	---
Odor, Threshold Odor Number	1	---	---
Nephelometer Turbidity, units	0.5	-	---
		parts per million	
Carbon dioxide	1.4	---	---
Total Hardness	9	---	---
Total Alkalinity as $CaCO_3$	290	---	---
Hydroxide Alkalinity	0	---	---
Carbonate Alkalinity as $CaCO_3$	30	---	---
Bicarbonate Alkalinity as $CaCO_3$	260	---	---
Bromide	Less/.1	---	---
Chloride	30	---	---
Fluoride	5	---	---
Iodide	Less/.1	---	---
Sodium	135	---	---
Potassium	4.4	---	---
Calcium	3.4	---	---
Magnesium	.5	---	---
Aluminum	Less/.02	.75	.82
Antimony	Less/.1	Less/.1	Less/.1

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Jackola Engineering Co.

LABORATORY NO 70934

	parts per million		
	1	2	3
Arsenic	Less/.005	.005	.005
Barium	Less/.02	.11	.12
Cadmium	Less/.002	Less/.002	Less/.002
Chromium	.005	.008	.005
Copper	.011	.006	.004
Ferric Iron	.05	---	---
Ferrous Iron	Less/.05	---	---
Lead	Less/.01	Less/.01	Less/.01
Nitrate as N	Less/.05	0.2	0.2
Nitrite as N	Less/.005	.01	.02
Iron	---	.80	1.00
Total Phosphate as P	Less/.05	.18	.15
Sulfate as SO_4	1	---	---
Sulfide	2.5	---	---
Sulfite as SO_3	Less/2.0	-	---
Mercury	Less/.001	Less/.001	Less/.001
Nickel	Less/.05	Less/.05	Less/.05
Silver	.019	Less/.002	Less/.002
Strontium	.10	.10	.11
Tin	Less/.001	Less/.001	Less/.001
Zinc	.017	.012	.008
Ammonia as N	---	.2	.1
Total Kjeldahl Nitrogen as N	---	.7	.5

	MPN per 100 mls		
Total Coliform	Less/2	1,600	920
Fecal Coliform	Less/2	920	350

Respectfully submitted,

Mike Nelson

MN:ks

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CLIENT Jackola Engineering Co.
575 Sunset Boulevard
Kalispell, MT 59901

LABORATORY NO 71287

DATE Sept. 29, 19[illegible]

REPORT ON WATER

SAMPLE IDENTIFICATION Marked: Sample #13 Camp Aqua, Hot Springs, MT
B. Hallstrom 9/8/80 11:30 AM
Geothermal Well 118°F 12PSI

TESTS PERFORMED AND RESULTS

Total Coliform, MPN per 100 mls	Less/2
Fecal Coliform, MPN per 100 mls	Less/2
pH, glass electrode at 25°C	8.5
Color, units	5
Odor, threshold odor number	1
Nephelometer Turbidity, units	0.5

	parts per million
Carbon Dioxide	1.5
Total Hardness	7
Total Alkalinity as $CaCO_3$	289
Hydroxide Alkalinity as $CaCO_3$	0
Bicarbonate Alkalinity as $CaCO_3$	259
Bromide	Less/.1
Chloride	29
Fluoride	5
Iodide	Less/.1
Sodium	150
Potassium	4.6
Calcium	6
Magnesium	.8
Aluminum	.04
Antimony	.15
Arsenic	Less/.005
Barium	Less/.02
Cadmium	Less/.002
Carbonate Alkalinity as $CaCO_3$	30

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CLIENT Jackola Engineering Co.
575 Sunset Boulevard
Kalispell, MT 59901

LABORATORY NO 71437

DATE Oct. 3, 1980

REPORT ON WATER

SAMPLE IDENTIFICATION Marked: 1) Sample #14 Camp Aqua, Hot Springs, MT
B. Hallstrom 9-15-80 11:15 AM
Little Bitterroot River Out flow

TESTS PERFORMED AND RESULTS 2) Sample #14 Camp Aqua, Hot Springs, MT
B. Hallstrom 9-15-80 11:00 AM
Little Bitterroot River In flow

	parts per million	
	1	2
Nitrate as N	2	0.1
Nitrite as N	.050	.020
Ammonia as N	.1	.1
Total Kjeldahl Nitrogen as N	.6	.5
Total Phosphate as P	.1	.1
Silver	Less/.002	Less/.002
Strontium	.20	.20
Tin	Less/.002	Less/.002
Zinc	.045	.015
Aluminum	1.6	1.9
Antimony	Less/.05	Less/.05
Arsenic	Less/.005	Less/.005
Barium	.13	.11
Cadmium	Less/.002	Less/.002
Chromium	.004	.004
Copper	.011	.009
Iron	1.2	1.3

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Chemistry Microbiology and Technical Services

CLIENT Jackola Engineering Co.
575 Sunset Boulevard
Kalispell, MT 59901

LABORATORY NO. 71437

DATE October 6, 19

REPORT ON WATER

SAMPLE IN IDENTIFICATION Marked: Sample #10 Well Tap Camp Aqua
Hot Springs, MT
B. Hallstrom 8-8-80 11:15 AM
118°F 11PSI Geothermal

TESTS PERFORMED AND RESULTS

Methane ---------- 0.13%

	parts per million
Ethane	Less/5
Propane	Less/5
Butane	Less/5

Respectfully submitted,

Laucks Testing Laboratories, Inc.

Timothy E. Runyan

TER:ks

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